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ORIGINAL ARTICLES.

I.—On a New Species of *Dipterus*.

By Dr. R. H. Traquair, F.R.S., F.G.S.

(PLATE II.)

From the Old Red Sandstone of Caithness, four species of *Dipterus* were originally named by Sedgwick and Murchison,[1] those being as follows:—

1. *Dipterus brachypygopterus*, anal fin short.
2. *D. macropygopterus*, anal fin long.
3. *D. Valenciennesii*, small in size, narrow in shape.
4. *D. macrolepidotus*, not characterized although figured.

It is evident from the figures of "*D. macrolepidotus*" that it does not belong to the same genus, even to the same family, as the other forms. Those have circular scales, whereas in "*macrolepidotus*," the scales are rhombic, and the head bones are clearly seen to be very different from those of *Dipterus*.

Nevertheless all the four "species" were reunited by Agassiz[2] into one, for which the name "*macrolepidotus*" was adopted, in the belief that the rhombic scales of that form were normal for the genus, and that their circular appearance in the others was due to wearing.

McCoy, however, correctly recognized the circular contour of the scales in the true *Dipteri*, and rightly refused to recognize "*macrolepidotus*" as the type of the genus, or as a *Dipterus* at all, and in fact proposed to transfer it to *Diplopterus*.[3] The other species proposed by Sedgwick and Murchison he restored to independence.

In his "Footprints of the Creator," Hugh Miller showed that Agassiz's *Polyphractus platycephalus* was the head of a *Dipterus*,[4] and not a Placoderm, but he did not seek to identify it with any previously described species.

Pander[5] of course confirmed McCoy's statement that *D. macrolepidotus*, of Sedgwick and Murchison, was not a *Dipterus* at all, but he reverts to Agassiz's idea as regards the three other reputed species. He united them again into one, for which he preferred the name

[1] Trans. Geol. Soc. 2nd ser. vol. iii. p. 143, tab. 15–17, 1829.
[2] Recherches Poissons Foss. Tome i. 1835–43, p. 115.
[3] Brit. Pal. Foss. Fasc. iii. 1855, pp. 590–592. I have made "*macrolepidotus*" the type of my new genus *Thursius*, Geol. Mag. November, 1888.
[4] 1861 Edition, p. 57.
[5] Pander (Dr. C. H.) u. d. Ctenodipterinen d. Devonischen Syst. 1858, St. Petersburg, pp. 1-32.

Valenciennesii, in order that the honour which the proposers of that name wished to confer on the distinguished French ichthyologist might not thereby be lost. As he also constantly uses the name *D. "platycephalus,"* it would appear that he considered these large crania also to constitute a distinct species.

After a careful examination of a very large number of specimens, including Sedgwick and Murchison's original types, in the Museum of the Geological Society, I have come to the same conclusion as Pander, namely, that the species, *brachypygopterus*, *macropygopterus*, and *Valenciennesii* are one. In the original type-specimens the apparent difference in the size of the anal fin in the first two reputed species is certainly due to the mode in which the specimens have been crushed, and as to *Valenciennesii*, I can only recognize in it a young example of the same common species. In the same way the adult condition of this species is to my mind represented by the large heads which have been called *"platycephalus."*

If we follow, with absolute strictness, the rules of the British Association in adopting the *first* of the specific names given by Sedgwick and Murchison, then we shall be compelled to use the very inappropriate one of *"brachypygopterus,"* as well as to deprive the name of Valenciennes of the homage which the discoverers of those fishes wished to offer to it. I hope, therefore, that the scientific world will grant an indulgence to Pander's view, and allow the name *Dipterus Valenciennesii* to stand for the species in question.

D. Valenciennesii is very characteristic of the Lower Old Red Sandstone of Banniskirk and Thurso, but it occurs also in the fish beds of the shores of the Moray Firth, as at Cromarty (Hugh Miller Collection); Lethen (Museum of Science and Art); Nairnside near Inverness (Wallace); Tynet (Collection of Rev. Mr. Kyle at Presholm, Banffshire).

Another and very distinct species occurs, however, at John O'Groats, where it was discovered by the late Mr. C. W. Peach in the same beds which yielded *Tristichopterus alatus*, Eg., and *Microbrachius Dickii* (Peach). It is mentioned in Dr. A. Geikie's list of Old Red Fishes,[1] and has been very briefly characterized by myself in a recent number of the Geological Magazine, where I proposed for it the name of *Dipterus macropterus*.[2] In the present communication I propose to give a somewhat more detailed description of this interesting form, accompanied by the figures on Plate II.

Ordinarily at least this species does not seem to have attained any great dimensions, as the specimens in the Edinburgh Museum average about six inches in length. In general form (Fig. 1) it resembles *D. Valenciennesii*, and the osteology of the head appears to be similar, though I have not found the ctenodont plates preserved in any instance. In Fig. 2 the outlines of the plates of the posterior part of the cranial buckler are given, from which it appears that they are rather shorter and broader than the corresponding plates in *D. Valenciennesii*, and there is an absence of the small plate which in

[1] Trans. Royal Soc. Edin. vol. xxviii. p. 452..
[2] Geol. Mag. for November, 1888.

that species is intercalated at the inner angles of the four plates in front of the median occipital. Fig. 3 represents the broad rounded operculum. The scales seem to be very thin, so much so that the internal skeleton is often seen through them, the axis being notochordal, and well-developed ribs being present. The leading feature of the species is seen in the form of the second dorsal fin, which has its base proportionally nearly twice as long as in *D. Valenciennesii*, while the shape of the fin, instead of being triangular-acuminate, is broad and oblong-rounded, the posterior rays being nearly as long as the anterior ones. Both pectoral and ventral fins are as in *D. Valenciennesii* "archipterygian" in their conformation, the pectoral being represented in Fig. 4. The first dorsal and the anal are narrow-lanceolate, the heterocercal caudal is triangular, and not bifurcated.

EXPLANATION OF PLATE II.

Fig. 1. *Dipterus macropterus*, Traquair, natural size. From the Lower Old Red Sandstone, John O'Groats, Caithness.
Fig. 2. Outline of posterior cranial plates, from another specimen.
Fig. 3. Operculum.
Fig. 4. Pectoral fin and shoulder girdle.

II.—Restoration of *Brontops robustus*, from the Miocene of America.[1]

By Professor O. C. Marsh, Ph.D., LL.D., F.G.S.

(PLATE IV.)

THE largest mammals of the American Miocene were the huge *Brontotheridæ*, which lived in great numbers on the eastern flanks of the Rocky Mountains, and were entombed in the fresh-water lakes of that region. They were larger than the *Dinocerata* of the Eocene, and nearly equalled in size the existing Elephant. They constitute a distinct family of Perissodactyles, and were more nearly allied to the Rhinoceros than to any other living forms.

The deposits in which their remains are found have been called by the author the Brontotherium beds. They form a well-marked horizon at the base of the Miocene. These deposits are several hundred feet in thickness, and may be separated into different subdivisions, each marked by distinct genera or species of these gigantic mammals.

The author has made extensive explorations of these Miocene lake-basins, and has secured the remains of several hundred individuals of the *Brontotheridæ*, which will be fully described in a monograph, now well advanced towards completion, to be published by the United States Geological Survey. The atlas of sixty lithographic plates is already printed, and the author submitted a copy to the Section. The last plate of this volume is devoted to a restoration of *Brontops robustus*, one-seventh natural size, and a diagram enlarged from this plate to natural size was also exhibited.[2]

[1] Abstract of a paper read before Section D of the British Association for the Advancement of Science, at the Bath meeting, Sept. 7th, 1888.

[2] The present Plate (IV.), one twenty-fourth natural size, shows a reduced copy of the same restoration.

The skeleton represented in this restoration is by far the most complete of any of the group yet discovered. It was found by the author in Dakota, in 1874, and portions of it have been exhumed at different times since, some of the feet bones having been recovered during the past year. It is a typical example of the family, and shows well the characteristic features of the genus and species which it represents.

The most striking feature of the restoration here given, aside from the great size of the animal, is the skull. This is surmounted in front by a pair of massive prominences, or horn-cores, which are situated mainly on the frontal bones. The nasals contribute somewhat to their base, in front, and the maxillaries support the outer face. These elevations, or horn-cores, vary much in size and shape in the different genera and species. They are always very small in the females.

The general form of the skull and lower jaw is well shown in the figure. The prominent occipital crest, the widely-expanded zygomatic arches, and the projecting angle of the lower jaw, are all characteristic features. In general shape, the skull resembles that of *Brontotherium*, but may be readily distinguished from it by the dental formula, which is as follows:—

Incisors $\frac{2}{1}$; canines $\frac{1}{1}$; premolars $\frac{4}{4}$; molars $\frac{3}{3}$.

The presence of four premolars in each ramus of the lower jaw is a distinctive feature in this genus. This character, with the single, well-developed lower incisor, marks both the known species.

The number of teeth varies in the different genera. The form of the teeth, especially in the molar series, is more like that in *Chalicotherium* and *Diplacodon* than in any other known forms. The teeth in the allied genus *Brontotherium* have already been figured and described by the author.

The vertebræ are somewhat similar to those of the existing Rhinoceros. In the present genus, *Brontops*, the neural spines of the dorsal vertebræ are elevated and massive. There are four sacral vertebræ in this genus, and in the known species the tail is short and slender, as in the individual here described.

The ribs are strong and massive. The sternal bones are compressed transversely. The exact form of the first one is not known with certainty, and is here restored from the Rhinoceros. This is the only important point left undetermined in the restoration.

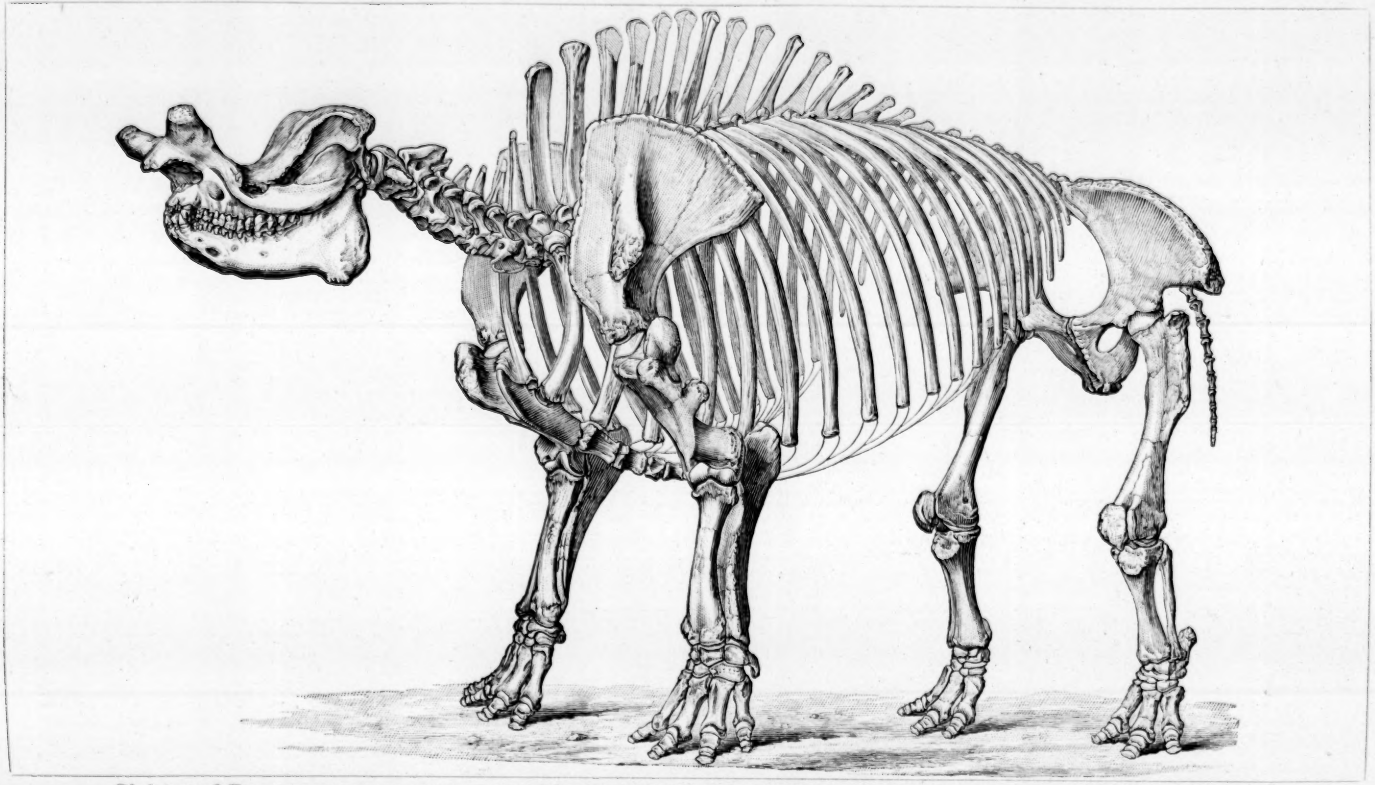
The fore limbs are especially robust. The humerus has its tuberosities and ridges very strongly developed, and the radius and ulna have their axes nearly parallel. There are four well-developed digits in the manus, the first being entirely wanting.

The pelvis is very wide and transversely expanded, as in the Elephant. The femur is long, and has the third trochanter rudimentary. The tibia and fibula are quite short. The calcaneum is very long, and the astragalus is grooved above. There are only three digits in the pes, the first and fifth having entirely disappeared.

Diplacodon of the Upper Eocene is clearly an immediate ancestor of the *Brontotheridæ*, while *Palæosyops* and *Limnohyus* of the Middle

Skeleton of BRONTOPS ROBUSTUS, *restored by Prof. O. C. Marsh, from the Miocene of Dakota, North America.*

One twenty-fourth natural size.



Skeleton of BRONTOPS ROBUSTUS, *restored by Prof. O. C. Marsh, from the Miocene of Dakota, North America.*

One twenty-fourth natural size.

Eocene are on the more remote ancestral line. The nearest related European form is the Miocene *Chalicotherium*. No descendants of the *Brontotheridæ* are known.

Menodus, *Megacerops*, *Brontotherium*, *Symborodon*, *Menops*, *Titanops*, and *Allops*, all belong to the family *Brontotheridæ*, and their relation to the genus here described, and to each other, will be fully discussed in the monograph, to which reference has already been made.

III.—Notes on Altered Igneous Rocks of Tintagel, North Cornwall.

By W. Maynard Hutchings, Esq.

(*Continued from page* 59.)

COMING along the cliffs from Boscastle towards Tintagel, at the part just seawards of the village of Trevalga, and between the outlying rocks known as "Short Island" and "Long Island," we see one or two limited outcrops of a schistose rock different from the surrounding slates, shales, etc. A thoroughly good sight of it is not, however, obtained till we reach the extreme north side of Bossiney Cove, a little way south of Long Island, when a very fine exposure of the sheet in question is observed, lying in among the sedimentary rocks, sharply marked off from them at contact, so that the junction-lines can be seen distinctly even from some distance.

It dips seawards in the cliff, and a very little way inland it rises to the surface and ends abruptly in an escarpment facing towards Trevalga. To the north, towards Boscastle, the sheet disappears and passes away under the quarries in the cliffs opposite the Growar rock. Going southwards it is not seen anywhere in the cliffs at the back of Bossiney Cove, which has been eroded through it; but at the south side of the Cove a section of it is again seen, similar to the one at the north side, the corresponding inland escarpment, on a larger scale, facing towards the village of Bossiney. The distance across the Cove in a straight line is nearly exactly a mile.

Passing through the neck of land which separates Bossiney Cove from the little cove next following it, the sheet is again exposed along the shore, here dipping steeply into the sea. The configuration of the land does not here lead to the formation of a prominent escarpment looking inland, but a small outcrop is seen here and there towards the village of Trevena (or Tintagel as it is called).

The sheet now disappears;—the mass of sedimentary rocks in which are the slate-quarries on the church glebe, curving seawards, covers it up in the cliffs, and there is no valley or broken ground to cause an exposure of it inland. It is thus hidden for a distance of rather over a mile and a quarter. Supposing it to be continuous, it is again seen at the north end of Trebarwith Strand, where it rises from beneath the slate-quarries and continues along in one uninterrupted exposure in the cliffs right away to the south end, a distance of three quarters of a mile. That what is seen at Trebarwith is really a direct continuation of what is seen at Bossiney Cove seems very little open to question. The direction of strike, position with regard to the slates, mode of occurrence, thickness and general

structure and composition, all appear to affirm it. In the Trebarwith cliffs it is again dipping steeply towards the sea. The upper few yards of it only are seen, the deeper portions underlying the beach. For a great part of the distance, and indeed wherever the rocks have not been disturbed by falls of cliff and landslips, the contact with the overlying sedimentary rocks is very sharply defined.

At the south end of the Strand the sheet disappears under the sedimentary rocks of Dennys Point, and so far as I am aware, it does not show again in the cliffs going southwards; certainly not for some three miles or so examined by me wherever accessible. Whether or not it has any connection with the igneous rocks near Port Isaac I do not know.

Near the south end of the Strand a valley, with a road, comes down to the shore. A little way up this road good sections of the entire thickness of the sheet are obtained, near the little village of Trenow and on the opposite side of the valley. It here again forms escarpments in which its upper and lower contacts with shales are sharply defined, and is again cut off abruptly as at Bossiney.

We can thus trace this sheet of rock, from north to south, for $3\frac{1}{2}$ miles. Its thickness may, on a rough average, vary from 70 to 100 feet. It doubtless originally continued some distance inland. De la Beche speaks of some parts of it (the northern) as connected with rocks several miles away, so that it evidently formed part of a very considerable igneous mass, which was older than any of the rocks already noticed.

Considered petrologically this occurrence is very interesting. Macroscopically, the chief observable components are green chloritic minerals and calcite. At some points micas more or less replace the chlorite. Pyrites and magnetite are seen in varying amounts, and at some parts epidote crystals in plenty may be noticed with the naked eye. Foliation is highly developed throughout, always coinciding with the cleavage of the slates and shales above and below. The texture of this foliation varies in every degree, from a fissility almost equal to that of a slate to a series of bands or layers of considerable thickness.

Both texture and mineralogical composition vary so much at different points that it would be equally useless either to attempt to give one description that should apply to the whole of the sheet, or to give detailed accounts of all of the series of sections I have examined from different parts. A better general idea will be conveyed by picking out and describing a few of the most strikingly characteristic examples.

At several places the rock is seen to be very coarsely laminated, layers of comparatively soft chloritic or micaceous material alternating with others of a hard, compact, non-foliated stony substance. This is seen most strongly exemplified towards the south part of Trebarwith Strand, where the layers of the stony material are as much as $1\frac{1}{2}$ to 2 inches thick in some cases, the softer layers being rather less. A serrated form results from weathering at these parts of the cliffs, the soft layers wasting away and leaving the hard ones projecting.

Where this coarse lamination is most developed it would almost lead one to believe that it represented an original stratification, or bedding, of different materials; but this impression is much weakened by the fact that this coarsest structure can be traced, in a short distance, passing gradually into finer and finer foliation, and finally into rock in which the chloritic and stony materials are so closely interwoven, so to speak, as to be no longer separable by eye or lens.

The material of the hard layers is of a slightly bluish-grey colour. It sometimes contains numerous crystals of magnetite, but beyond this and occasional grains of calcite no separate minerals can be made out with a lens. It effervesces so briskly with acid that this, and its appearance, might easily cause it to be set down as calcite, but its hardness and the fact that fragments do not dissolve, nor even disintegrate, in acid, show that its main component is not calcitic.

Portions of contiguous, very coarse, hard and soft layers were submitted to microscopic examination, and a description of them is interesting, not simply as bearing on this special form of occurrence, but also because, with slight modifications, a more or less intimate mixture of these two materials makes up a great part of the entire sheet of rock.

The material of the hard layers may be best described by saying that grains of calcite, and grains and more or less imperfect crystals of felspar, are set in what may for convenience be called a sort of "ground-mass" of felspar, chlorite, small grains of calcite, muscovite flakes, and quartz, with much iron ore.

The larger bits of felspar are mostly of quite indefinite and rounded outlines, though a few of them show a certain amount of regular shapes. Some of them show well-developed cleavage, but twinning is so rare as to be practically absent. All are quite water-clear, but are more or less full of minute flakes of muscovite.

In the "ground-mass" felspar very much predominates. Its degree of intermixture with the other materials varies, so that at some parts of a slide the whole forms a very fine-grained mosaic, while at others it is much more coarsely compounded. Grains of felspar of ample size to permit of optic tests for its discrimination from quartz are plentifully dispersed throughout. It is all brilliantly water-clear, and no sign is anywhere seen of any definite forms, nor of any twinning. The quartz is wholly secondary, and is rather irregularly dispersed, as single larger grains and as a fine-grained mosaic, either alone or in intermixture with felspar and chlorite. Flakes of muscovite abound throughout the entire mass. Sphene is very plentiful in transparent colourless grains and as rather larger, brownish, less transparent bits; and a good deal of leucoxene is seen in various stages of progress to granular aggregates of sphene. A little rutile is present, mainly in the larger bits of chlorite.

Iron ores are diffused in very great abundance all over the sections. Crystals of magnetite predominate, but there is a great deal of rounded, crushed and quite indefinite form down to almost a powdery condition. Among this, small, ragged, flat, thin, plates may be seen, and some thicker tabular bits, but there is nothing

which could safely be set down as ilmenite, unless it be a few extremely thin flakes, faintly translucent, with brown colour, in some of which sagenitic rutile is visible. These appear to be micaceous ilmenite. It may be as well to remark here that throughout all the sections examined from this sheet of rock, magnetite is the only iron ore which can be specified with certainty. Crystals of it are very abundant, and it is seen that though the greater part of it was formed prior to, or during, the foliation of the rock, much has also been formed since. Much, if not nearly all, of the rounded, flattened and totally crushed material is also magnetite; the deformation of crystals under pressure and movement is seen in various stages. Larger plates, with or without leucoxene, which could be classified as ilmenite, are not seen anywhere. Tabular fragments of fair size occur often enough, and leucoxene is present frequently with them; but this, as Mr. Teall points out (British Petrography, p. 167), is not enough to warrant their being set down as ilmenite, because the same result might be equally obtained from titaniferous magnetite in decomposition. The presence in the rock of a noticeable amount of leucoxene, together with the abundance of sphene and rutile, make it probable that ilmenite was originally present in considerable quantity, but is now represented mainly by alteration-products. As bearing on the nature of the original material of this sheet the question as to ilmenite is, of course, of considerable importance, and I have looked carefully for any cases of its definite occurrence.

The corresponding soft layer does not really differ essentially in nature from the hard layer. The chlorite has increased much in quantity and is in larger pieces. Muscovite also is present in larger amount and in larger flakes and crystals, and also in good-sized patches. Calcite is less in quantity, while quartz again is much increased. For the rest, there is the same ground-mass of felspar, chlorite, etc., only that it is not so regularly diffused. There are plenty of large grains of water-clear felspar, and several bits show more or less of twinning. There is a prevalence of very intensely undulous extinctions in the felspars and quartz grains, due to great mechanical stresses. This is more marked here than in any other part of the sheet. The same is true of the minerals of the hard layer, but not in quite so great a degree. The iron ores are very much more in a *crushed* condition here too. A high power shows the diffusion of minute grains and crystals of rutile all through the sections, together with other grains and microlites which are indeterminable.

Microscopic study of these layers, therefore, does not bear out the idea that they are connected with any original bedding of materials of different nature. Much as they now differ in physical condition and general appearance, their constitution is mineralogically the same, and, it is an interesting question as to how this local separation into bands has taken place, and how it is that while the soft layers are highly foliated and split easily into thin pieces, the hard layers have not a trace of such foliation or cleavage.

From the microscopic evidence of great stress in some of the minerals of both layers, it seems safe to conclude that both have been alike subjected to the pressure and movements which caused the foliation of the entire sheet, and that their separation is thus not due to any subsequent causes. And if, as seems reasonable, the passage of these sharply-separated layers into quite close inter-foliation negatives the idea of any prior bedding, it would appear probable that this curious structure was developed concurrently with the ordinary foliation, when the earth-movements took place which have so much affected all the rocks of this district.

As before stated, much of the entire sheet of rock consists of the materials of these layers just described, variously intermixed, together with one or two other minerals. At some parts chlorite and calcite increase almost to the exclusion of felspar, at others felspar again plays a more prominent part. Biotite and muscovite vary from total absence to great predominance, and epidote again, which at some parts is very abundant, disappears entirely at others. Large bits of felspar are the exception, most of it being in smaller grains and fine mosaic, and with one exception, nothing at all approaching to *original* felspar is seen.

Specimens from one point along Trebarwith Strand show the presence of a large amount of actinolitic hornblende. It is very pale green, almost colourless, and very slightly dichroic. It occurs with chlorite, into which much of it is in course of alteration. Felspar is in rather largish bits in these sections. A large amount of epidote is present, of yellow colour and rather strong dichroism. It is all in broken crystals and large, detached, irregular fragments, which frequently, at some distance apart, show their former unity. Sections cut across the schistosity of the rock show very plainly that the movements which caused foliation broke and dragged asunder fine large crystals of epidote, and gave an approximately parallel arrangement to a portion of the fragments. This question as to the age of epidote and other minerals, relatively to the foliation of the rock, will be referred to again. In the present instance there is no doubt that epidote crystals were formed in great plenty *before* the movements took place, and there is no sign of any having been developed since.

Hornblende was not seen in any other sections, but would doubtless prove to be present at other parts of the sheet if more specimens were taken. At a point only a few yards away it had totally disappeared, and epidote was present only in very small amount.

Specimens from both sides of Bossiney Cove are interesting owing to the very large development of mica and of epidote.

Some of the rock from the south side is made up mostly of biotite, with chlorite and numerous large crystals of epidote. Much of the biotite has a greenish tinge, and is at many points more or less altered to chlorite, much of which appears to have originated in this manner. Most of the biotite is in large irregular flakes, which lie with their flat sides parallel to the schistosity and are drawn out with the chlorite into long, slightly curving lines. But there is also a good

deal of biotite which is not so arranged, but lies with its flat sides in various directions, mostly vertical or highly inclined to the foliation. It occurs as very numerous individuals with sharp outlines and boundaries of tabular crystals. It is all quite fresh and more transparent than the other form, and as it has so evidently not been in the least degree affected by the rock-movements, it appears to be younger than the irregular flakes, and to have been developed since the foliation took place.

Felspar, some of it twinned, is well represented, and there is quartz as usual. Rutile is very abundant in some parts of sections, as good-sized crystals and grains. The epidote crystals are more numerous and larger than in any other specimens examined. Many may be picked out with a penknife, and their forms examined with a lens, or even with the naked eye; but smaller crystals, not perceptible without the microscope, are also plentiful.

These epidotes lie, by far the greater number, with their long axes parallel to the plane of foliation, lying in various directions in this plane. Hence slides prepared parallel to foliation show hardly any cross-sections of the crystals, while such sections predominate in slides prepared transversely. Dichroism is moderate, varying from colourless to pale yellow. The crystals are mostly very perfect. The usual elongation in the direction of the orthodiagonal is so strongly developed that the length is mostly very great in proportion to the thickness. The forms do not present anything unusual. The ends are in no cases bounded by definite planes. Cross-sections parallel to the clino-pinacoid, show mostly six-sided forms bounded by the faces 001, 100, and $\bar{1}01$, but owing to the disappearance in some crystals of the faces 100, there are also many rhombic sections. Twinning is frequent, both as simple binary twins and as others in which several lamellæ are inserted between the two main portions. It is developed not only in the larger crystals, but also in the the smaller microscopic individuals. The occurrence of twinning in small epidotes is stated to be not very frequent.

In the sections of rock now under consideration the epidote has not, as a rule, been very much affected by the shearing which has developed a very high degree of "flow" structure in mica, chlorite, calcite, iron ores, etc. There are many crystals which do not show signs of having suffered any kind of stress or disturbance at all, and which would incline one to believe that they had been formed subsequently to the foliation of the rock. But there are also others which have been broken or bent, some to even an extreme degree, though actual separation of fragments is rare; and a large number of others which have not been so severely affected still show that their internal structure is modified in harmony with the foliation of the other minerals, lines of iron ore continuing their straight or curving courses right through the epidote sections. Also the layers of mica, chlorite, etc., are sharply curved and bent over the angles of the crystals lying in their way. It is clear, therefore, that much of the epidote here was in existence before foliation took place, though there is some of it of which it would not be possible to decide

whether it is subsequent to foliation, or whether it is only that some crystals, for some reason, escaped all sign of stress.

Some of the rock from the north side of Bossiney Cove differs from that just described in the fact that it contains a large amount of muscovite, which mineral was absent in the former case. The muscovite here exceeds the biotite in quantity and is, indeed, the main component of the rock. It occurs mainly in small flakes, lying parallel to the plane of foliation, and felted together into compact layers. Sections cut parallel to these layers show many patches in which the muscovite is almost wholly unmixed with other minerals, and which, notwithstanding the presence of many flakes which lie in transverse directions, behave between crossed Nicols as if only one larger individual were present, giving sharp and distinct optic figures in convergent light. In other patches there is more or less intermixture of chlorite, or of biotite-flakes, giving a greenish or yellowish colour and causing blurred and indistinct optic figures. It is in transverse sections that the layers in question are best recognized as being built up of countless muscovite flakes compacted together.

Similar occurrences of muscovite take place at several other points in the sheet, but it was not seen anywhere else in such large amount.

The biotite of this occurrence resembles in all respects that of the one last described, including the apparent formation of a younger lot of it, but the individuals of the latter are fewer, and are larger and less sharply defined. Felspar is absent in this case; quartz is rather plentiful. There is no rutile in crystals of any size, but under high power the entire rock is seen to be full of very minute crystals and grains of it.

Epidote is almost as plentiful here as in the last instance, and its arrangement in the rock is practically the same, but it is not in quite such large crystals.

The sections show that here the epidote has been intensely affected by the rock-movements, not only being broken and dragged asunder, and curved and twisted in all degrees, but being in some cases squeezed into lenticular streaks of crushed material, which is, so far as my observation goes, rare in the case of epidote, and tells of very great stress indeed. So far as these special sections go, there seems no question that *all* the epidote was formed prior to the foliation of the rock.

Lying in among the micaceous and chloritic material at the south side of Bossiney Cove I found an occurrence of rock which deserves special mention, because it differs so very much in many respects from anything else seen in this sheet. It is dark grey in colour, very hard and compact, with quite a splintery fracture. Neither macroscopically, nor microscopically, is there the least sign of any foliation. The part exposed, or at all events seen at any accessible part of the outcrop, was limited to a layer of perhaps a foot and a half in thickness and four to six feet in length, forming a projecting ledge in among the rest of the rock. It made the impression of being part of a thin bed lying more or less parallel with the foliation

of the sheet, but it was not possible to make sure whether this was the case, or to get any idea of its extent.

The microscope shows this rock to be made up of much felspar, with a great deal of chlorite, some secondary quartz, a little calcite, a few flakes of biotite, and large amounts of epidote and of granular sphene.

Most of the felspar is water-clear and indefinite, but there are also a good many well-defined columnar forms, of various sizes, showing twinning, binary, and multiple. In the amount of individualized felspar this rock stands out quite distinct from any other specimens from the sheet, as it does also in regard to *quantity* of felspar present.

Many of these felspar crystals are bent and broken and show curved twinning-lines, and a very large proportion of them, as well as of the water-clear bits and the quartz grains show strongly undulous extinctions. The epidote also is much broken up and the ends of many crystals are surrounded by quantities of small crushed fragments. But for the absence of foliation, this rock seems to have undergone quite as much stress as any other part of the sheet. Were it not so, one would be rather inclined to think it might be a later igneous matter intruded into the already altered rocks of the sheet. It appears, however, more likely, in view of the similarity of its alteration-products, both in nature and extent, to those of the other specimens examined from various parts of the sheet, that it is really a part of the same original mass, which has escaped foliation for some reason we cannot explain. Were this foliated like the rest, it would differ only from some other specimens in being more felspathic; and even this difference might very probably disappear, owing to development of mica and other minerals from the felspar, which there is reason to believe would be brought about during the process of foliation.

A thorough study of this interesting sheet of rock would require further attention in the field, and the examination of a much larger series of sections than I have prepared. From what I have adduced above it seems reasonably certain that the entire mass is of igneous origin, but there does not seem to be any basis whatever on which to decide as to whether the original material was a massive rock, consolidated from a molten condition, or whether it was a fragmental deposit of tuff or ash. It seems likely that where such great alterations have taken place as are here shown, all clue to the original nature and condition of the rocks would be equally destroyed in either case.

Whatever was the original nature of the material, we see from the microscopic record that even prior to the great earth-movements of the district it had undergone very complete alteration under the ordinary influence of chemical action, and doubtless much pressure from the masses of sedimentary rocks piled above it. Secondary hornblende had formed and probably mostly passed in its turn into chlorite. Calcite was everywhere abundant and much quartz had been deposited.

Epidote was plentiful at some parts, as was probably also mica of both kinds, though it is most likely that much of the muscovite now seen was formed at the time when the great crushing and shearing took place. The same may be said of the sphene which is so plentiful in nearly all the sections, and which probably originated from leucoxene during the same period, together with much rutile. The great pressure and movement of the mass, we may suppose, also caused the re-generation of the decayed original felspars and the formation of the water-clear material which now plays so large a part in these schists.

It can be seen that since the foliation took place some chlorite and quartz, and very large amounts of calcite have been deposited. This later calcite may easily be distinguished in all the sections, and penetrates the rocks through and through, filling up also all the joints and cracks. At some outcrops it has increased so much in amount that it makes up most of the rock, as in the sides of the valley opposite Trenow.

IV.—On the Occurrence of a Variety of Picrite (Scyelite) in Sark.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

LAST summer I had the pleasure of passing a fortnight in the Channel Islands under the guidance of my friend the Rev. E. Hill, who has done so much to elucidate their geology. During our short visit to Sark we spent some hours in the beautiful little cove called Port du Moulin, examining the interesting sections of the hornblende-schist and underlying gneissic rocks. I was wandering on the beach looking at the wave-worn boulders which afford most interesting studies of the structure of this crystalline series, when my eye was attracted by one which differed much from the rest, and resembled a dark-coloured serpentine of a slightly exceptional character. With some difficulty, owing to its form, I detached a tolerable specimen, and on examining the fresher surface, felt convinced that I had found a rock composed chiefly of an altered olivine and a silvery talc-like mineral. At the time it recalled to my memory in some respects the scyelite described by Prof. Judd, though it did not exhibit the conspicuous porphyritic structure of that rock. The conjecture proves on microscopic examination to be accurate, and I subjoin a short description.

Macroscopically the rock exhibits a compact invisible-green or nearly black ground-mass, interrupted by specks and larger grains of a pale-grey mineral with a rather silky or silvery lustre; the grains being interrupted by black spots as is common with bastite. The water-worn surface shows an irregular mottling of black and grey. On using a lens the latter part suggests the presence of two minerals, one having a more fibrous structure and silky lustre; the other a more lamellar structure and more silvery lustre. Some small flakes of a brownish mica can be distinguished, and one or two grains of fair size are distinctly green in colour, resembling

penninite. The specific gravity of the rock is 2·88.[1] Examined with the microscope the rock is seen to be composed mainly of the following minerals:—

1. Olivine, in process of conversion into serpentine. The grains, in diameter from about ·07″ downwards, exhibit the characteristic network structure produced by 'strings' of serpentine, often blackened, as usual, with opacite, but give brilliant chromatic polarization in the interstiees occupied by the unaltered olivine.

2. A pyroxenic mineral, often in larger grains, most of which is either colourless or of a very pale greenish-grey tint. Evidently more than one variety or species is present. Occasionally the cleavage of a hornblende may be recognized; but much, especially of the greener variety, has an acicular habit, though the needles lie parallel; thus, though sections be taken at right angles, the characteristic cleavage of hornblende is much more rarely seen than one would expect. These acicular or possibly platy groups often have their divisional planes spotted with opacite and are traversed by thin strings of serpentine. They extinguish simultaneously and usually at angles below 20°, but occasionally range up to 24°. Moreover, here and there grains occur with augite cleavage or augite extinction, colourless or a very light brown, some of which, with crossing Nicols, have a curious pallid 'moribund' aspect. These are commonly surrounded by a felted mass of a fibrous mineral, which gives brilliant tints with the polarizing apparatus. It occurs elsewhere in the slide, and sometimes almost resembles a ground-mass. I regard it as a form of actinolite. On the whole I believe that the original mineral of the rock was augite, perhaps a little variable in composition, and that, as has often been noted in picrites, we now find it in different stages of alteration into varieties of hornblende.

3. A mica-like mineral. Some of this exhibits a distinct though rather weak dichroism, changing from colourless with vibrations perpendicular to the basal plane to pale brown with vibrations parallel with it. Occasionally there is a slight 'edging' of pale dull green. This mineral, when rotated from the positions of extinction (parallel with the cleavage planes), exhibits rather brilliant colours, and the peculiar mottled or 'shot' look so common in a mica. The remainder (and greater part) of the mineral is perfectly clear and colourless, and between the crossed Nicols only varies from black to a dull pallid grey or white. Rods or plates of opacite are frequently present between the cleavage planes. I have no doubt that the former is a magnesia-biotite, probably similar to that described by Prof. Judd[2] in the scyelite of Caithness, and the latter represents an alteration product of the same. I find a rather similar mineral in some of my slides of chlorite schists, and Prof. Judd's analysis does not differ much from that of a penninite, where the percentage of magnesia is rather low. Certainly a rather large plate in one of my hand-specimens much resembles that mineral. There are also

[1] Kindly determined for me by Mr. J. H. Holland in Prof. Judd's laboratory.

[2] Quart. Journ. Geol. Soc., 1885, vol. xli. pp. 401–407.

occasional elongated enclosures, shuttle-shaped in section, like those of calcite figured by Prof. Zirkel.[1] These often appear to be composed of a fibrous or lamellar mineral rather similar to the microlithic actinolite already mentioned. The larger grains of the mica inclose small grains of olivine, and grains or crystals of this hornblendic mineral. In some cases needles of actinolite, in length up to about ·04″, pierce it obliquely, like pins, making an angle of about 35° with the cleavage planes. The penetrating power of acicular hornblende has often been noticed,[2] so I regard these as probably secondary. In other cases they lie, as above described, between the cleavage planes.

4. Grains of iron oxide (in addition to much scattered opacite and small interstitial plates or rods, especially in the mica). These are no doubt original constituents, but I think that from their peculiar outline they have in some cases received secondary augmentation. Most of these grains are perfectly black and opaque, but occasionally a deep brown tint is just discernible at the edges, and two grains are in parts fairly translucent and of a distinct dull green colour. Hence it is probable that the mineral is chromiferous, and varies from magnetite or chromite to picotite.[3]

One would not be surprised to find some variety of rhombic pyroxene in the rock, but I have failed to identify it, and am disposed to refer all the cleared and colourless mineral to mica, rather than to bastite or bronzite. But this group of rocks is so variable that another investigator may find something which I have not noticed.

Some of the grains, I may observe, which I take for altered mica or a chlorite, exhibit a remarkable twin structure—singularly like the lamellar twinning of plagioclase—one set of bands extinguishing parallel or nearly parallel with the cleavage planes, the other at an angle with it which in one case is actually 18°, though generally it is less than 10°. Beyond this it has no resemblance whatever to a felspar. It might possibly be an enstatite, but I think the reference to the mica is more probably correct. I have seen similar twinning, mimicking both the 'albite' and 'pericline' types in an undoubted altered pyroxenic mineral—probably enstatite—in a serpentine from Carn Sparnack (Lizard), and in other cases.[4] Probably we shall not be wrong in adopting Prof. Judd's explanation, and referring the structure to molecular strains, which might well be set up in the changes which this mass has undergone.

It is evident from the microscopic examination that this rock is very closely allied to the scyelite (altered mica-hornblende picrite) described by Prof. Judd.[5] The published analysis of the latter, as

[1] Microscopic Petrography of 40th Parallel, pl. v. fig. 1.

[2] Quart. Journ. Geol. Soc. vol. xxxiii. pp. 910, 913; Teall, British Petrography, p. 162.

[3] Wadsworth, Lithological Studies, p. 170, etc.

[4] One of my slides from the Rill (Lizard) is full of small crystals of a mineral which I formerly took to be enstatite (altered), but I now see has a very close resemblance to the bleached mica.

[5] *Loc. cit.* pp. 402, 405.

well as the microscopic study, show that the principal minerals occur approximately as follows: Hornblende, 58·5; altered olivine, 22·0; altered mica, 18·5 per cent. I think that the proportions in the Sark rock are not very different. Hence it is the result of the alteration of a picrite (using the word in the sense in which I have been accustomed to employ it), rather than of a normal peridotite, viz. of a group transitional between the latter and the dolerites.[1]

So far as we could see this rock does not occur *in sitû* in the cliffs at Port du Moulin, but during both our visits there was a rising tide, and we were not able to reach nearly to low-water mark. Moreover, we found so much of interest in the hornblende-schist and its associates, that we had no time to search thoroughly the craggy slopes above. I have, however, little doubt that the rock occurs *in sitû* at no great distance. The boulder—more than half a cubic yard in solid contents—is far too large to have been brought as ballast,[2] for it could only have been shipped by means of a crane, and nothing larger than a fishing boat (except in case of a wreck) would be likely to touch at Port du Moulin. Besides, I do not know of any seaport at which such a rock occurs.

Since our visit, Mr. Hill has called my attention to the following passage in Ansted's Geology of the Channel Islands (p. 264): "An important vein of serpentine and steatite, with asbestos and talc, has been traced crossing the central part (of Sark) near Port du Moulin." This vein, Mr. Hill tells me, he did not find when engaged in the work for his paper on Sark; and as the term 'serpentine' was often used rather vaguely at the time when Ansted wrote, he did not attach much importance to it, and the matter had even escaped his memory at the time of our visit. The coast of Sark is very precipitous, and if the dyke is not well exposed, it might easily be missed, even by so careful a worker as my friend. It would now seem probable that Ansted was substantially right in his identification, and that the rock which I have described comes from his 'vein.'

As there is no probability of my returning to Sark for years, if ever, I publish this note in the hope that some one will trace this interesting rock to its home. No doubt it will occur as a dyke, and there is a special interest in finding it here, because the hornblende-schist of Sark is lithologically identical with much of that from the Lizard peninsula, where varieties of serpentine are also intrusive in the crystalline series.

I may add that, after my return to England, Mr. Hill found a picrite in Alderney, though it is nearer to the olivine-dolerites than that which forms the subject of the present note; this will be described in a paper which he is preparing on the geology of that island.

[1] It is, I think, inconvenient to apply the term picrite both to these rocks and to members of the peridotite group, composed of olivine and augite, where the former mineral dominates, and the percentage of magnesia nearly equals that of silica; for the latter (probably rarer) form a new name might be coined, if augite-peridotite will not suffice.

[2] Afterwards I noticed two or three others of smaller size.

V.—On the Recent Discovery of the Remains of the Mammoth in the Valley of the Darent.

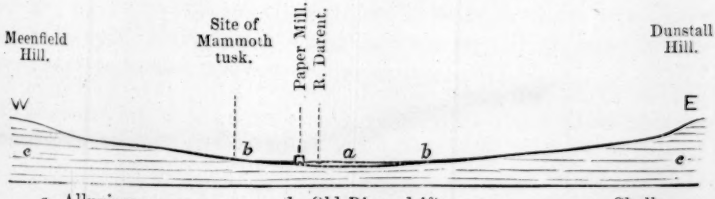
By Prof. J. Prestwich, M.A., F.R.S., V.P.G.S., etc.

ABUNDANT as the remains of the Mammoth and its associated group of Pleistocene Mammalia are in the adjacent valleys of the Medway and the Cray, none have been yet recorded in the valley of the Darent, to which the Mammoth no doubt commonly resorted at the same time. One reason may be that this valley is very bare of Drift, and between Dartford and Otford there is not a single pit in the little drift-gravel that is met with.

Shallow and narrow sections, 3 to 8 feet deep, were, however, opened out in the drift beds last summer for the purpose of the new drainage works for the village of Shoreham. The drift was there found to consist mostly of light-coloured loam, sand and chalk debris, full generally of angular and unworn flints. No organic remains were found in passing through the village, but at its north-west corner, in carrying a trench from the main road down to and under the river, the workmen came, at the depth of 3½ feet, upon the tusk of a Mammoth, about 6 feet long, lying in a bed of sand and gravel. It was in an extremely friable condition, and fell to pieces in getting it out. A piece only one foot long reached me.

I found the usual loam, chalk and flint rubble here replaced by a bed of sharp sand and subangular gravel, no doubt of fluviatile origin. I succeeded, by washing some of the materials, in obtaining a few fragments of shells, which I would refer with some doubt to *Pisidium*, *Planorbis* and *Helix*, but they were extremely scarce and friable, and I could not obtain a single entire specimen. The gravel consisted of subangular flints, pebbles of chalk, subangular fragments of chert and ragstone from the Lower Greensand of Sevenoaks, and Tertiary flint pebbles, showing the flow of the river to have been then as now from south to north.

Section across the Valley of the Darent by the Paper-Mill at Shoreham :—Distance about 1 Mile.



a. Alluvium. *b*. Old River-drift. *c*. Chalk.

The height of the spot where the remains were found is 30 feet above the present stream, or 202 feet above Ordnance datum. The earlier works for the main drainage had already shown that the Alluvial beds of clay in the valley were from eight to ten feet thick, with an underlying bed of gravel and chalk rubble five to six feet thick. Therefore the old river at that Quaternary time must have flowed on a bed some 30 to 40 feet higher than at its last stages.

Above the village the chalk slopes are entirely bare and without traces of a higher-level river-drift. The foregoing woodcut gives a section of the valley at this spot (see p. 113).

No other remains were found here, but at Eynsford, three miles lower down the valley, the foreman informed me that they had found, at about the same depth, but only 20 feet above the river, the entire tooth of a Mammoth. At Green Street Green in the adjacent valley of the Cray remains of the Mammoth, together with those of the Woolly Rhinoceros, Musk Ox, Horse, Ox and Deer, etc., have been met with, and in the associated beds of loam I have found numbers of the small shells of *Pupa marginata*.

VI.—On a Breccia and an Altered Hornblende-Schist at Housel Cove, Lizard.

By Alexander Somervail, Esq.

THE rocks forming Housel Bay consist of the normal dark hornblende-schists with the exception of those out of which the charming little Cove bearing the same name has been formed, which holds nearly the central part of the Bay, facing the south-east.

The Cove has three small recesses, an east and a west, and a central one, which receives a small stream flowing into it; the whole, however, a few yards seawards forming one well-defined Cove.

On descending into the Cove one is immediately confronted by rocks presenting a very different aspect from the ordinary hornblende-schists of the adjoining area. A little careful attention on the part of an observer will also lead to the detection of a breccia in the centre of the Cove, close to the stream; the best guide to it being a slickensided surface on which it will be found resting.

The breccia is only a few inches in thickness, and is confined to the under surface of the rock overlying the slickenside. It is composed of numerous broken crystals of a greenish-white felspar, varying in size from mere specks up to others of nearly an inch in length, set in a reddish paste formed out of the rock by crushing. It also contains angular and semi-rounded fragments of its own mass, and what looks like small well-rounded pellets of quartz coloured red by the presence of iron. Besides these there is some extraneous like matter possibly introduced or formed during the process of its being cemented together. Altogether its origin is without doubt due to a thrust, or other movement of the one mass of rock over the other with such force as to shatter and groove their opposing faces.

The rock throughout the entire extent of the Cove (which appears to define its limits) weathers into various shades of yellowish-brown and red, and when broken up with the hammer is seen to have a very near approach to a felsite, which it also resembles in composition, being composed principally of felspar and some quartz almost to the exclusion of the hornblende. It also contains scattered throughout its mass some steatitic or serpentinous mineral of greenish colour arranged in (veins and) small concretionary forms. It is, however, evidently only an altered condition of the hornblende-schist, as it con-

tains large eyes of that rock. It can be studied to much advantage towards the east end of the Cove, where the huge eyes of the hornblende-schist are distinctly seen gradually to pass into the felsitic rock, which in turn passes into the hornblende-schist at either extremity of the Cove, thus precluding the idea of the former rock being intrusive in the latter.

In my short communication[1] to the MAGAZINE for December last, I referred to the various rocks and minerals formed out of a magma cooling under different conditions, or by its mineral constituents separating during the cooling process. In the present instance we note what seems equally referable to subsequent mechanical and chemical change after the rock had passed into a consolidated state, as attested by the breccia and the highly altered condition of the hornblende-schist. This is but one among the many examples of these Lizard schists passing into each other. Such a passage may also be noted between the hornblende, the mica-diorite, the mica-schist, and other varieties. In the field we catch them, as it were, in the very act of alteration into each other, at least we can observe them in all their transition stages, and these from their decidedly squashed appearance, their frequent lenticular, irregular, and other inconstant characters, betray their dynamic and secondary origin. Still it must, I think, be conceded that however much dynamic metamorphism may have altered these Lizard rocks from their original mineral aspects, every such change in the main has been predetermined by some difference in there primary composition.

VII.—On some Physical Changes in the Earth's Crust.

(Part II.)

By CHARLES RICKETTS, M.D., F.G.S.

(*Continued from* p. 53.)

SUBTERRANEAN landslips differ from landslips occurring in cliffs along the coast, and in escarpments elsewhere, in that, a fissure having been formed and its sides become separated (Figs. 2 and 3 *a*), so that they are without support along the line of division,

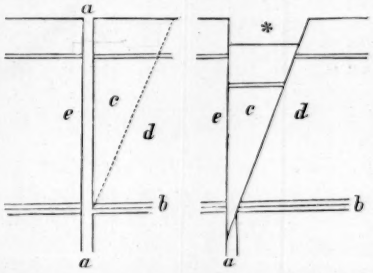


Fig. 2. Fig. 3.

it may happen that by the giving way of some soft or unconsolidated stratum (*b*), at any depth, from a few feet only, down to the molten nucleus, wedge-shaped masses (*c*) extending parallel to the fissure

[1] On a Remarkable Dyke in the Serpentine of the Lizard.

would break off (*d*) and slipping down strike against the opposite wall (Fig. 3*e*) and thus fill up the fissure. An immediate effect of the impulse must be the occurrence of an earthquake shock, more or less intense, according to such various conditions as the size and weight of the falling mass, the space through which it falls or slips, the structure of the rocks involved, and other circumstances. If from a subsequent change this enlarged area is placed in a restricted position, the compression thus caused not only affects to a certain extent the dip of the strata, but causes the 'fault-rock' included within the crevice to be compressed into slabs lying parallel to the sides of the fault, forming a coarse but true slaty-cleavage. This cleavage is of very frequent occurrence in the north and south or main faults in the Triassic sandstone of the district around Liverpool.

In the Presidential address to the Liverpool Geological Society for the Session 1872—1873[1] it was explained that the occurrence of earthquakes (not including some connected with volcanic eruptions) was due to the formation of faults, each of which must register at least one, or probably a succession of earthquake shocks. The examination of strata has as yet discovered no other cause than the formation and settling down of geological faults, capable of producing all the varied phenomena recorded as accompanying earthquakes, including that of the huge sea waves, which not infrequently are one of their most destructive accompaniments, when occurring near the coast; being probably caused by the rushing of water into the trough (Fig. 3*) formed by the depression of the faulted mass, immediately succeeded by the consequent rebound; at all events these waves are not due to the *shock* of the earthquake, for some occurring in the near neighbourhood of the sea, as in that of Essex (1884), and in North America, at Charleston, S. Carolina (1886), were entirely unaccompanied by such disturbances of the water.

The reporter of an excursion along "the line between the Highlands and the Lowlands," made in 1875 by the Geological Class of Edinburgh University, under the guidance of Professor Archibald Geikie, noticed the fact that Comrie, celebrated for its earthquake shocks, lies almost directly over the great fault extending across Scotland, 170 miles in a direct line from Stonehaven to the Isle of Arran. He spoke of this as being "the first attempt to connect the abundance of tremors at that place with the geological structure of the ground underneath."[2] Professor J. Milne, F.R.S., of the Imperial College of Engineering, Tokio, infers "that in Japan faults are still being formed, and that the earthquakes there are to us the announcement of these fractures;"[3] "also that certain earthquakes and faults are closely related phenomena, the former being an immediate effect of the latter."[4] Dr. H. J. Johnston-Lavis, F.G.S.,[5] and Mr. G. K. Gilbert, of U.S. Geological Survey,[6] refer the oc-

[1] Proc. Liverpool Geological Society. An abstract of this Essay ("On Fissures, Faults, Contortion and Cleavage," by Charles Ricketts) appeared in the GEOLOGICAL MAGAZINE, Vol. X. 1873, p. 202.

[2] Nature, vol. xii. p. 93. [3] Brit. Assoc. Report, 1881, p. 201.

[4] Earthquakes and other Earth Movements, by John Milne, F.G.S., 1886, p. 279.

[5] Nature, vol. xxiii. 1881, p. 498. [6] Nature, vol. xxix. 1883, p. 45.

currence of earthquakes to the formation of fissures described as "falling" or "slipping"; the blow thus occasioned being felt as an earthquake. Fissures and displacements likewise occur as the *effect* of the shock, in unconsolidated strata or in the banks of rivers; this latter was especially evident in that of Cachar, East Indies, in 1869; but instances have been recorded in which an extent of land has at the time of the shock separated and changed its level under such circumstances as are indicative of the formation of these faults having originated and *caused* the earthquake. Several have been described by Lyell,[1] and also by others.

On two occasions systematic attempts have been unsuccessfully made (by Mr. Robert Mallet after the Neapolitan earthquake of 1857;[2] and by Dr. Oldham with respect to that of Cachar in 1869;[3]) to discover the exact site, the cause of displacements, or the changes which originated the shocks, by tracing back the secondary effects to their source. Though in each case the near neighbourhood whence the shock originated was determined, the exact cause was not discovered.

Contortions of strata, even those of great extent, have very generally been attributed to secular cooling of the earth, consequent on its crust being compressed into a less space as it followed the cooling and therefore sinking nucleus. But if subsidence has occurred from such a cause, how is it that, with an increasing loss of caloric, the areas supposed to have been depressed in this manner have been again raised, it may be to a greater height than that which they previously occupied? Sir Charles Lyell remarked that "the wide extent in North America, and in parts of Russia, of Carboniferous, Devonian, and Silurian strata, which, although upraised above the sea, continue almost as level as when the beds were first thrown down beneath the waters, clearly demonstrates the limitation of the agency, to which great foldings and contortions of stratified rocks have been due, to very confined spaces in each epoch;"[4] but as these localities are to a great extent situated in regions of excessive cold, in some so intense that the ground is frozen to the depth of many hundred feet, it, I think, likewise follows that, if loss of heat can induce flexures, it must be, as in these instances, to a very limited extent.

Mr. T. Mellard Reade, F.G.S., considers "there is a fallacy in the reasoning which attributes the corrugation of the earth's surface to the contraction of the nucleus" and "has arrived at the conviction that the cooling of our earth has not extended to such a depth that we need consider the internal contraction as a geological cause."[5]

The Rev. Osmond Fisher, F.G.S., goes farther; he has calculated

[1] Principles of Geology, vol. ii. chap. xxviii.-xxx.

[2] Report of the Royal Society of London to investigate the great Neapolitan earthquake of 1857.

[3] Memoirs of Geol. Survey of India; vol. xix.; also Quart. Journ. Geol. Soc. vol. xxviii. p. 255.

[4] Quart. Journ. Geol. Soc. vol. vi. p. xlii.

[5] Origin of Mountain Ranges, p. 125.

what would be the effects of contraction of the globe in cooling, upon the supposition of the temperature of solidification being respectively 7000° Fahr. and 4000° Fahr. The result arrived at is, that in the former case the contraction of the radius would be six miles, and in the latter two miles only; that the mean heights of the surface-elevation formed by compression would amount in the one to 19 feet and in the other to only two feet;[1] that is, as I understand him, the mountains caused by this supposed contraction of the earth in cooling might, in one case, be so high as a moderate sized cottage, in the other, as that of a dog-kennel. This being so, well may Mr. Fisher exclaim, "*Nascuntur montes, genuit quos ridiculus mus!*;" which may be translated, "The mountains are born, an insignificant mouse is their mother!" This calculation corroborates what has been previously alluded to as to the comparatively small effect subsidence has in causing lateral pressure or a tendency to cause contortions. Too much, far too much, has been accredited to the effects these movements could produce in causing lateral pressure. Certainly in many instances where there has occurred great disturbance of the strata, by their becoming contorted and folded and dipping various ways, depression to a great extent has also taken place; whereas in others, where it can be proved that there has been at least as great an amount of subsidence, the strata continue as level or nearly so as when first deposited. The difference between the conditions in the different localities is so great, that the contortions cannot be referred to vertical movements common to each.

There are other flexures dependent on minor local causes not necessary to be considered at the present time.

An important step towards determining the causes of foldings in strata must be to ascertain, so far as is possible, at what period they were produced. Where they exist to the greatest extent, especially in deposits formed of fine mud, cleavage has also been frequently developed, and the particles have so changed their relative position that the embedded fragments of rock lie with their longer diameter obliquely to the stratification, and the flatter sides parallel to the direction of the cleavage; included fossils are distorted, the lower portions being often pressed into their substance, whilst the upper have become elongated; indicating that the expansion has been from below upwards. Both contortion and cleavage arise from lateral compression; it is therefore assumed that the same power that has caused the one has at the same time also caused the other. Such changes must have taken place before the original pasty condition of the strata became so consolidated as to prevent, on the application of pressure, movement of the particles of which the mass consists amongst themselves. This might be at any period prior to these clayey rocks becoming solidified by their being raised above the sea level, and the consequent drainage of their contained water, or from other causes. Great power has been exerted in the production of these flexures; but there is no indication of violence; their state

[1] Phil. Mag. Jan. 1888; see also for Nov. 1887.

coincides with a suggestion of Lyell's, that "they have been the result of intense pressure, so moderated as to be just sufficient to overcome the resistance opposed to it; and that this motion has been as insensible as the unfolding of the petals of a flower." [1]

Professor A. Favre of Geneva gives in "La Nature" illustrations of experiments [2] in which layers of plastic clay were laid upon a sheet of caoutchouc, stretched one-third more than its length; on being allowed to resume its normal dimensions, the bands of clay were diminished to that extent, and became greatly contorted. The experiments were conceived for the purpose of illustrating the method of formation of the great inequalities on the earth's surface, such as mountains, etc., by means of lateral thrust or crushing, which are considered by him to be due to the cooling of the earth. They do not appear at all applicable in explaining the cause of eminences and depressions in the contour of the land; they more nearly represent those foldings and contortions of strata which have been universally attributed, since the time of Sir James Hall, to lateral pressure; but it is too much to conceive that from any contraction, whether by loss of heat or otherwise, extensive areas have been compressed into a third less than their original dimensions; as this is a condition of by no means infrequent occurrence in geological formations, the cause of the compression and consequent foldings of strata must be searched for in other directions.

(*To be continued.*)

VIII.—On a Cœluroid Dinosaur from the Wealden.

By R. Lydekker, B.A., F.G.S., etc.

In going through the remains of Chelonia preserved in the British Museum I came across two vertebræ from the Wealden of the Isle of Wight, which had been inadvertently included in that series. These specimens (B.M. No. R. 901) formed part of the collection of the late Rev. Mr. Fox, and clearly indicate a small Dinosaur allied to the genus *Cœlurus*.

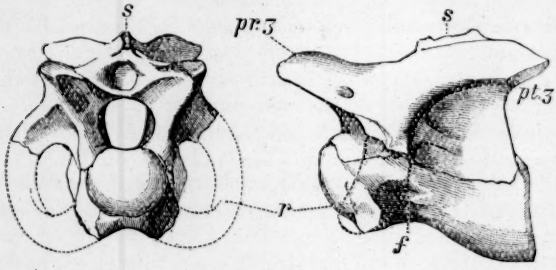
Both specimens belong to the cervical region, and are precisely similar; but whereas one is almost entire, the other has lost nearly the whole of the neural arch. The former specimen is represented of two-thirds the natural size in the accompanying woodcut; from which it will be seen that it is practically entire, with the exception of the loss of the greater part of the ribs (see p. 120).

The chief characters of this specimen may be summarized as follows. The vertebra is considerably elongated, with a markedly opisthocœlous centrum, of which the terminal faces are oblique. The arch is comparatively low, with only a slight ridge to represent the neural spine. The ribs were anchylosed to the arch and centrum, and (from the contour of the basal portion) were evidently much bowed outwards. The sides of the centrum exhibit a pneu-

[1] Quart. Journ. Geol. Soc. vol. vi. p. lxiii.

[2] They are copied in "Nature," vol. xix. December 5, 1878, p. 103. The Rev. Osmond Fisher has reproduced one in "Physics of the Earth's Crust," p. 128, but does not coincide with the deduction Prof. Favre draws from the experiments.

matic foramen, and a fracture across the centrum of the imperfect specimen shows that the inner structure was completely honeycombed. The length of the centrum is 1·74 inches.



Anterior and left lateral aspects of a cervical vertebra of *Calamospondylus Foxi*; from the Wealden of the Isle of Wight, $\frac{2}{3}$ nat. size; *prz.* prezygapophysis; *ptz.* postzygapophysis; *r.* rib (restored); *f.* pneumatic foramen; *s.* neural spine.

These features show that the reptile to which these vertebræ belonged was closely allied to the genus *Cœlurus*, Marsh;[1] and it remains to indicate in what manner the two forms differ. Now, in the American *C. fragilis*, and also in *C. Daviesi*[2] of the English Wealden, the cervicals were longer than the present specimen, and while the anterior ones were opisthocœlous, the others were amphicœlous.[3] Again, the vertebræ of *Cœlurus* have the arch placed more forwardly on the centrum, so that the prezygapophyses project more in advance of the terminal ball of the latter; while the free posterior border of the rib is extended backwards to join the postzygapophysis, and thus forms a kind of penthouse over the side of the centrum. This penthouse seems, moreover, to cause a flattening of the lateral and upper surface of the arch, which is quite wanting in the present specimens; while the ridge representing the neural spine is much more elongated antero-posteriorly in *Cœlurus*.

Other minor differences can be seen by comparing the woodcut with the figures given by Prof. Marsh; but the above features are sufficient to indicate that the present form cannot be included in *Cœlurus*, if we use generic terms in the sense in which they have been generally accepted in the Theropoda, but that it clearly indicates a member of the same family.

Now, putting aside the specimen on which the genus *Thecospondylus* was based as being too imperfect to admit at present of any interpretation of its affinity;[4] the only other genus which appears to have been hitherto referred to the *Cœluridæ* is *Tanystrophæus* of the Trias, which Prof. Cope considers to be allied to *Cœlurus*. In the absence of figures of the American forms referred by Prof. Cope to *Tanystrophæus*, an exact comparison cannot be instituted between

[1] Amer. Journ. Sci. ser. 3, vol. xxi. p. 341, pl. x. (1881).
[2] See Lydekker, Cat. Foss. Rept. and Amphib Brit. Mus. pt. i. p. 156 (1888).
[3] In the definition of the *Cœluridæ* on p. 155 of the work last cited, the words in anterior region are omitted before the word opisthocœlous.
[4] Prof. Seeley has proposed to refer *Cœlurus Daviesi* to this genus.

its cervicals and the present specimens; but a marked distinction is evident by the amphicœlous character of the former. There is, however, in the Wealden the genus *Aristosuchus*, which appears to be allied in some respects to *Cœlurus*, and of which the type may be taken to be the sacrum.[1] Now the present specimens are much too large for that sacrum, and therefore clearly indicate a distinct species; while if the dorsal vertebra[2] referred to *Aristosuchus* be rightly associated, we have evidence not only of the generic, but also of the family distinction of the present form from the latter.

Seeing, therefore, that we have evidence of the generic distinction of this form from *Cœlurus* and *Tanystrophæus*, and also of its certain specific and probable generic distinction from *Aristosuchus*, I have ventured provisionally to regard it as the type of a new genus and species under the name of *Calamospondylus Foxi*. This genus being characterized by the opisthocœlous character of such of the cervical vertebræ as are known, and by the much shorter length of these vertebræ as compared with those of *Cœlurus*.

IX.—Note on the Deciduous Septa of *Ascoceras Murchisoni*, Barrande.

By Arthur H. Foord, F.G.S.

An interesting paper has lately been contributed to this Magazine (December, 1888, p. 532), by Dr. Gustav Lindström, of Stockholm, in which he announced his discovery of the earlier, or *Nautilus*-stage, as he termed it, in several specimens of *Ascoceras* from the Silurian of the Island of Gothland. I find, however, in looking over the supplementary volume of the Syst. Sil. du centre de la Bohême,[3] that Dr. Lindström's discovery has been anticipated by M. Barrande, who observed and described two of the normal chambers (*Nautilus*-stage, of Lindström) attached to a specimen of *Ascoceras Murchisoni* from the Silurian strata (Étage E) of Karlstein in Bohemia. I give here a translation of Barrande's description, together with exact copies of the figures accompanying it, and the explanations of the same. A copy of Dr. Lindström's figure is also added for comparison with Barrande's.

"We have always assumed, especially in the original description of the genus *Ascoceras*,[4] that there existed below the body-chamber a series of deciduous air-chambers which became successively detached from the shell by normal truncation. This supposition is confirmed by the specimen which we figure on plate 491. It is quite apparent that fig. 3 on this plate [see p. 122. Fig. 1] represents a specimen which is distinguished from all those before figured upon our plate 95, by the relative length of the septate part which remains attached to the body-chamber. This septate part, when examined,

[1] Lydekker, *op. cit.* p. 158. R. 178.
[2] *Ibid.* R. 178, a.
[3] Vol. ii pt. i. 1877, Supplém. et Série tardive, p. 98, plate cccxci. figs. 3–7.
[4] *Ascoceras* prototype des Nautilides, Bull. Soc. géol. de France, tome xii. p. 157, 1855.

shows distinctly two air-chambers of very unequal height, and bounded by three superposed septa, in the following order:—

"1. Terminal septum of the body-chamber, as seen in other examples of *Ascoceras*.

"2. Septum placed below the preceding, at a distance of about 7 mm. from the body-chamber. A like distance has never been observed in any other specimen in which two septa could be recognized below the body-chamber.

"3. Terminal septum, situated about 2 mm. below the preceding one, and constituting the abrupt truncation characteristic of the posterior extremity of *Ascoceras*.

"This truncated end is very distinct and has a smooth surface. The edge of the test is seen around its external border, and from

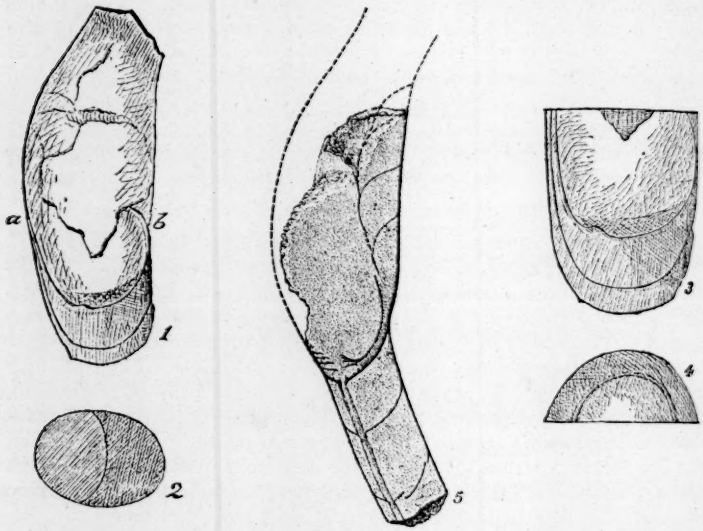


Fig. 1. Lateral view of *Ascoceras Murchisoni*, Barr., showing the body-chamber nearly complete, excepting the margin of the aperture. The lower part presents a longitudinal section, showing three very unequally spaced septa, abruptly truncated below.

Fig. 2. Transverse section of the same specimen, following the line *a*—*b* (Fig. 1).

Fig. 3. Lower extremity of the same specimen, enlarged twice, to show more clearly the three septa.

Fig. 4. Surface of terminal septum (pan coupé) of the same specimen; bordered by the edge of the test, which is here broken by natural truncation.[1]

Fig. 5. *Ascoceras*, after Lindström.

[1] Fig 7 of Barrande's plate, an enlargement of the ornaments of the test, is omitted, as unnecessary for the present purpose.

this border the test spreads over the external surface of the fossil, and exhibits the ornamentation characteristic of this species, consisting of a net-work of fine striæ.

"The phenomena just described clearly prove that, in *Ascoceras*,

as in various genera of Nautiloid shells, the earlier part of the shell was composed of a series of air-chambers, and that these chambers were periodically thrown off by natural truncation.

"Judging by the form of the lower part of the specimen under discussion, it may be presumed that the series of deciduous septa was considerably elongated, and that truncation took place at successive periods.

"The length of the specimen described is 48 mm., and its greatest breadth 18 mm. . . . .

"This very instructive fossil was found at Karlstein, together with numerous examples of the same species, in the limestones of band *e* 2. It may be added that this specimen has been in our possession for many years, but it was not until the spring of 1875 that we decided to have a longitudinal section made at its posterior extremity [see Fig. 1], which resulted in the discovery of three unequally spaced septa."

Although, as we have seen, Barrande was the first to observe and to describe the deciduous septa of *Ascoceras* in Bohemia, Dr. Lindström's recent discovery of similar septa in Swedish specimens is extremely interesting, and warrants us in hoping that by still further research the initial chamber of *Ascoceras* may be brought to light, and thus complete our knowledge of this singular genus.

NOTICES OF MEMOIRS.

I.—Om Lias i Sydöstra Skåne. Af Joh. Chr. Moberg. Kongl. Svenska Vetenskaps-Akademiens Handlingar. Bdt. 22, No. 6. Stockholm, 1888.

On the Lias in South-Eastern Scania. By J. C. Moberg. 4to. 86 pp. with One Map and Three lithographed Plates.

From several places in the neighbourhood of Kurremölla in the south-east of Scania, Dr. Moberg discovered in beds of shale and sandstone associated in places with thin beds of coal, a series of fossils differing materially from those occurring in the Liassic strata of other parts of the same province. The forms which mostly belong to lamellibranchiate Mollusca are carefully described and figured in the present memoir. They number in all 64 species, of which 52 are determinable, and 25 new forms. From a comparison of the known forms, the author concludes that the Kurremölla Lias fauna represents the zones of *Ammonites Bucklandi*, *Am. zipihus*, and *Am. Jamesoni*, and that although there is a considerable number of fossils belonging to the Lower Lias, yet the most characteristic forms indicate that it is equivalent to the lowest part of the Middle Lias. It is thus on the same horizon as the Lias of the Island of Bornholm and higher in the series than the Liassic strata of the north-west of Scania. G.J.H.

II.—List of the Fossil Faunas of Sweden. Edited by the Palæontological Department of the Swedish State Museum (Natural History). II. Upper Silurian. Stockholm, 1888, Norstedt and Sons. 8vo. 29 pp.

THIS second part of the List of Swedish fossils, prepared by Prof. G. Lindström, contains the names of the species occurring in the Upper Silurian strata of that country. The principal locality in which rocks of this period are developed is the Isle of Gotland, from which place no fewer than 960 species are recorded, and, according to Prof. Lindström, this number will be considerably increased when all the fossil groups are thoroughly worked out. Of those already studied in detail the Crustacea number 133 species, the Gasteropoda 192 species, the Brachiopoda 150 species, and the Crinoidea 180 species. The Silurian strata in Gotland are ranged under eight divisions, corresponding approximately with the divisions of the same rocks in this country, and the range of each species in the different divisions is carefully noted. Of the other localities in which Silurian rocks occur in Sweden, those in the province of Scania have yielded 75 species, in Dalecarlia 22 species, and in Jemtland 48 species. G. J. H.

III. — Öfversigt af Sveriges Mesozoiska Bildningar. Af Bernhard Lundgren. (Ur Lunds Universitets Årsskrift, Tom. xxiv.), Lund, 1888.

A Review of the Mesozoic Formations of Sweden. By Bernhard Lundgren. (From the Yearbook of the University of Lund.) 4to. 37 pp.

AS is well known, the Mesozoic strata of Sweden are exposed *in situ* only in a very limited tract of the southern part of that country, and they are but very imperfectly represented by two groups of beds; a lower, belonging to the Trias and older beds of the Lias; and an upper, belonging to the newer beds of the Cretaceous system. In the present memoir Prof. Lundgren discusses in detail the distribution, the petrographical characters and the fossil contents of these various beds, as well as their relationship to the corresponding strata in other countries. The lower series of beds are included in (I.) the Kågaröd-group, which is regarded as probably of Keuper age; and (II.), the Coal-bearing beds, of Rhætic and Liassic age. The interval between the Lias and the Upper Chalk is entirely unrepresented, and it is probable that the South of Sweden was a land surface at the time. The Cretaceous beds belong to the Lower and Upper Senonian and the Danian stages. A list of the literature on the subject is appended. G. J. H.

REVIEWS.

I.—Prof. Dr. von Zittel on Palichthyology.

Karl A. von Zittel. Handbuch der Palæontologie. Palæozoologie. Band III. Lief. I. II. (R. Oldenbourg, Munich, 1887–88.)

THE latest two instalments of Prof. von Zittel's valuable "Handbuch" form the first part of the third volume, which is to be devoted entirely to the Vertebrata. The parts consist together of 436 pages, extending as far as the end of the section upon Amphibia; and no less than 333 pages are occupied with the discussion of the Pisces. Woodcuts, as usual, are numerous and excellent; and in the last-named section these are over 300 in number, while many are so novel for a text-book that to glance over the pages is quite refreshing.

The introductory remarks upon the class of Fishes, in which we are somewhat astonished to find *Amphioxus* still included, occupy fifty pages, and form perhaps the most philosophical concise account of the anatomy of the fish-skeleton that has hitherto been published. The scales are first treated in detail, and then other dermal structures, like spines and fin-rays; next follow the teeth; and, lastly, the various parts of the endoskeleton. Full references are given to the principal memoirs; and the description of the anatomy is followed by some brief remarks upon the systematic arrangement of the class.

As remarked by Prof. Cope,[1] the classification adopted is one of the very few remnants of a bygone era of Ichthyology to be noted in the work. Moreover, family-terminations are often used in ordinal-names, and ordinal-terminations in family-names; and whereas, in some cases, the vernacular designation of the families is placed after the scientific name (e.g. *Notidanidæ* Grauhaie), the non-German reader especially is liable to be perplexed in other cases where precisely the same punctuation is employed and an author's name is substituted (e.g. *Scylliolamnidæ* Hasse). However, these are small matters, and when the rich store of information is indexed, the work will be as convenient for reference as it would have been had the principles of the more precise systematists of the present day been strictly followed. The summary is, indeed, so complete to the date of publication that in reviewing the work it seems most profitable to note the bearing of later researches upon the facts and speculations recorded.

Dismissing the unnecessarily introduced "Leptocardii," the Cyclostomi follow for consideration. The only fossil remains said to have been referred to this "sub-class" are the well-known *Conodonts*, and these problematical bodies are regarded as being so doubtfully assignable to the Vertebrata, that they are treated only in a long footnote. Zittel and Rohon's conclusion is adopted, that they are almost certainly annelid jaws.

[1] American Naturalist, 1887, p 1014.

Selachii.

In the lengthy section upon the Plagiostomi (about 50 pp.), special prominence is given to the important researches of Kölliker and Carl Hasse upon the structure of the vertebral column; and there are several clear diagrams to illustrate the conclusions of the Breslau Professor, who has succeeded in determining, at least generically, the detached fossil vertebræ. The *Cyclospondyli*, *Tectospondyli*, and *Asterospondyli*, of Hasse, are respectively defined, and then follows a brief account of the earliest traces of the Selachian fishes hitherto discovered, in the form of *Onchus*, *Thelodus*, etc.

The systematic description naturally commences with the primitive Notidanidæ, and the long-lived *Notidanus* itself is recorded as the only undoubted member of the family as yet recognized; the diagram illustrating the dentition of the genus, however, is accidentally overturned, the lower jaw being placed uppermost. It may be well also to add that a fossil representative of *Chlamydoselache* is now known from the Pliocene of Italy.[1]

Of the extinct family of Hybodontidæ, as defined by Zittel, the recognized generic types are similarly but few; no well-known forms besides *Hybodus* and *Cladodus* being regarded as referable to this division with certainty. More, however, is known of the type genus than the author records; reference might have been made to the characters of the shagreen, and especially to Charlesworth[2] and Day's[3] determination of the so-called *Sphenonchus* as a cephalic dermal spine of *Hybodus*. At the present time, also, we are acquainted with a portion of the head and vertebral column of a closely allied fish from the Chalk.[4] In fig. 62, the letters *a* and *b* are transposed.

The Cochliodontidæ follow the Hybodonts, and form an unsatisfactory "family," of which no structural characters beyond those of the teeth (except perhaps in *Pleurodus*) are known. Full references are given to the numerous detached teeth named by Agassiz, McCoy, St. John, Worthen, Newberry, and James W. Davis; to which is added a notice of Traquair's important discovery of the jaw of *Psephodus* in the Scotch Carboniferous. A new genus, *Chalcodus*, is also founded upon a jaw, having each ramus armed with a single thin dental plate, from the Kupferschiefer of Thüringia. So far as external features are concerned, this fossil is very suggestive of the teeth of *Squaloraja* from the Lias, and it would be interesting to know to what extent there is an agreement in microscopical structure.

To the still-surviving Cestraciontidæ, *Orodus*, *Acrodus*, *Strophodus*, and other genera are referred, and excellent illustrative figures are given. Owen's mistake of assigning to *Cestracion* a side-view of the jaws of *Myliobatis* is, however, repeated (fig. 69). The arrangement adopted again reminds us of the extreme imperfection of our knowledge of the extinct allies of *Cestracion*. The true *Acrodus*

[1] J. W. Davis, Proc. Zool. Soc. 1887, p. 542.
[2] Mag. Nat. Hist. N.S. vol. iv. (1839), p. 245, pl. iv.
[3] Geol. Mag. Vol. II. (1865), p. 565.
[4] Proc. Zool. Soc. 1886, p. 218, pl. xx.

(not including the so-called *A. falcifer*) passes imperceptibly into *Hybodus*, so far as the dentition is concerned; and in the two genera the dorsal fin-spines, head-spines, and shagreen are identical. Nevertheless, *Hybodus* is the type of the "Hybodontidæ"; *Acrodus* is by common consent admitted into the Cestraciontidæ. Already, the progress of research begins to suggest emendations. *Ptychodus* proves to have not the slightest affinity with the Cestracionts;[1] and it is somewhat misleading to mention in connection with the teeth of this genus the large ribbed spines, which are afterwards correctly referred to *Pelecopterus* [=*Protosphyræna*] in the section on Ichthyodorulites, though truly pertaining to a Teleostean fish.

The Scylliidæ and Scylliolamnidæ are not of much palæontological importance, but the succeeding Lamnidæ and Carchariidæ naturally occupy a considerable space for full treatment. Doubt is rightly cast upon the supposed Carboniferous representatives of these families, and *Sphenodus*, of Jurassic age, is recorded as the earliest undoubted member of the Lamnidæ yet known. *Meristodon* is given as a synonym of *Oxyrhina*, but the type-specimens in the British Museum are fragments of Hybodont teeth; *Otodus* is retained, though with a reference to its suggested demolition by F. Noetling; and *Corax*, as usual, is also placed in this family. In the description of *Carcharodon*, the omission to note *C. longidens*, Pillet,[2] is perhaps unfortunate, this tooth being supposed to occur in beds equivalent to the Maastrichtian, while all other undoubted representatives are Tertiary. On p. 83 *Alopiopsis* is misprinted *Hopiopsis*, and this ought to be placed as a synonym of *Protogaleus*, Molin (Sitzungsb. k. Akad. Wiss. Wien, vol. xl. 1860, p. 583).

The Spinacidæ, with cyclospondylic vertebræ, are next considered, and the Liassic *Palæospinax* holds its accustomed place as their earliest recognized representative. Quite lately, however, this fish has been found to possess an anal fin, and to have many vertebræ feebly asterospondylic; and these characters, together with those of the teeth, remove it to a position among the Hybodonts.[3] The so-called *Spinax primævus*, from the Lebanon Chalk, is assigned to *Centrophorus* (after Hasse), and fragments of other genera and species are recorded both from the Chalk and Tertiaries. But it is time that the Cretaceous "*Spinax major*" were entirely omitted from lists, such smooth dorsal spines being indeterminable; and Egerton[4] and Hasse[5] have both shown that some, if not all, of the fossils in question are Cestraciont.

The primitive family or group of *Xenacanthidæ* follows. The remarkable preservation of the Continental Permian specimens of *Xenacanthus* renders possible a somewhat detailed account of the hard parts of this genus, and thus throws considerable light upon

[1] Quart. Journ. Geol. Soc. vol. xliii. (1886), p. 121; Proc. Geol. Assoc. vol. x. (1888), p. 295.
[2] Mém. Acad. Sci. Savoie, [3] vol. ix. 1883, p. 277.
[3] Geol. Mag. [3] Vol. V. (1888), p. 499.
[4] Mem. Geol. Surv. Dec xiii. (1872), pl. ix.
[5] Neues Jahrb. 1883, vol. ii. p. 66.

the affinities of the family. The characters of the pectoral fins, indeed, would justify its being placed in a much more isolated position than that it occupies, as already suggested by Cope[1] from features in the structure of the skull, and lately by C. Brongniart[2] from more general considerations. *Xenacanthus*, *Pleuracanthus*, and *Orthacanthus* are separately described; though, with Mr. J. W. Davis,[3] we fail to appreciate the distinctive features.

The Squatinidæ introduce the series of tectospondylic Selachians. This family is first recorded from the Lithographic Stone of Bavaria, and in addition to the ordinary recognized species of this age, the author includes the fragmentary fossil from the corresponding formation in Ain, France, named *Phorcynis catulina* by Thiollière. A figure of a most perfect example of *Squatina alifera* from Eichstätt is given, showing for the first time that the median fins are arranged precisely as in the living species.

At this point Dr. von Zittel defines and explains the "Unterordnung Batoidei" (mainly after Günther), and includes therein the remaining Selachian families. The Pristidæ (Saw-fishes) are believed to be represented by vertebræ in the Chalk (very doubtfully determined), but remains of the characteristic snout have not hitherto been recognized from beds below the Eocene. Most of the latter fossils are referred to *Pristis*, and a few from Egypt to *Propristis*, Dames. To these may now be added *Amblypristis*, Dames (*antea* p. 28).

The definition of the Pristiophoridæ demonstrates the illogical nature of the "Unterordnung," one *family*-character being noted as "Kiemenöffnungen seitlich gelegen, nicht auf der Unterseite," while on the previous page exactly the reverse ("Kiemenspalten auf der Unterseite") occurs unqualified in the definition of the major division. Only doubtful vertebræ of Pristiophoridæ are known from the Tertiaries; but the Liassic *Squaloraja polyspondyla* is also assigned to this family—a position from which later researches have necessitated its removal.[4]

The Psammodontidæ are an extinct family of Rays with great crushing teeth, confined to the Carboniferous period, and the symmetrical teeth named *Copodus* are placed here equally with the more typical paired teeth of *Psammodus* itself. Nothing, however, is known of these fishes beyond their fragmentary dentition. The Petalodontidæ, of Carboniferous and Permian age, are a little more satisfactorily understood, a portion of the body of one genus, *Janassa*, having been discovered in the Continental Kupferschiefer. Teeth like those named *Petalodus* are exclusively adapted for cutting, while in the most specialized genus, *Janassa*, the coronal edge is blunt and overturned, so that the dentition is admirably suited for crushing and trituration. Fig. 109 ought to be named *Polyrhizodus magnus*, McCoy; and the tooth shown in fig. 111

[1] Proc. Amer. Phil. Soc. 1884, p. 577.
[2] Comptes Rendus, April 23rd, 1888.
[3] Quart. Journ. Geol. Soc. vol. xxxvi. (1880), p. 321.
[4] Proc. Zool. Soc. 1886, p. 527.

certainly does not belong to *Ctenopetalus*, but has lately been named *Callopristodus* by Traquair.[1] *Peripristis* was defined by O. St. John, not Newberry and Worthen.

The Myliobatidæ are next described, and Cope's *Apocopodon*, from the Chalk of Brazil, is quoted as their forerunner. Here must now also be added *Ptychodus*. Numerous species of the common genera are cited, and the complete specimen of *Myliobatis Gazolai*, discovered by Baron de Zigno at Monte Bolca, is referred to. The genus *Zygobatis* is retained distinct from *Rhinoptera*.

In the Rhinobatidæ, the Jurassic *Spathobatis* is said to be only distinguished from the living *Rhinobatus* by the less jointed character of the pectoral fin-rays, and a fine figure of *S. mirabilis* (original 1·7 m. long) is given. *Asterodermus* and *Belemnobatis* are also included in this family. The Rajidæ follow, and are mostly known only by fragments of the dermal armour. The Liassic *Arthropterus* and *Cyclarthrus* are doubtfully placed here; and there are a few teeth of *Raja*, besides the placoid asperities so common in the Tertiaries. In the *Trygonidæ* are included fossil representatives of *Trygon*, *Tæniura*, *Anacanthus*, and *Urolophus*, besides two supposed extinct genera, *Alexandri*[*n*]*um* and *Xiphotrygon*, all from Tertiary strata. To the Torpedinidæ are assigned *Torpedo* (*Narcobatus*) *gigantea* from Monte Bolca, and vertebræ of *Astrape* from the North German Tertiaries; also the Cretaceous *Cyclobatis*, which really belongs to the Trygonidæ.[2]

Holocephali.

The Holocephali occupy the succeeding nine pages, and all except two are placed in the family Chimæridæ. The dentary plates are described as "teeth," but Newton's determination of those of the upper jaw as "premaxillary" and "maxillary" is regarded as erroneous, and these are merely termed respectively "vorderer Oberzahn" and "hinterer Oberzahn." The Devonian *Rhynchodus* and *Ptychodus* appear as the earliest representatives of the family. *Ischyodus* is next treated in detail, with a figure of von Meyer's *Ganodus avita* (Lith. Stone), which is considered a member of the genus. *Ganodus* is retained for the Stonesfield fossils, originally so named by Egerton; and the new generic name of *Metopacanthus* is proposed for Egerton's *Ischyodus orthorhinus*, from Lyme Regis. Then follows an account of the later Chimæroids, so far as known; and a distinct section is devoted to the Liassic *Prognathodus*, and a new allied genus, *Chimæropsis*, from the Lithographic Stone of Bavaria. Dr. von Zittel considers that the so-called maxillary teeth of *Prognathodus* are really mandibular, and that the curious elongated spine-like tooth pertains to the lower jaw. *Chimæropsis* has subsequently been more completely elucidated by J. Reis in the Palæontographica.

The description of the Selachian and Chimæroid fishes is concluded by a long section upon Ichthyodorulites, which treats of all doubtful

[1] Geol. Mag. [3] Vol. V. (1888), p. 85.
[2] Geol. Mag. [3] Vol. IV. (1887), p. 508.

spines, besides several whose relationships have already been discovered. We prefer to restrict the vague term, however, to the fossils of the first category. The classification is not very satisfactory. *Erismacanthus* cannot be claimed to have much similarity to a dorsal fin-spine, nor *Harpacanthus* to an unsymmetrical pectoral; they seem much more like such head-spines as those of *Hybodus*, *Acrodus*, the Chimæroids, and *Squaloraja*. An unfortunate error, moreover, occurs in fig. 130, in which *Tristychius arcuatus* is named *Harpacanthus arcuatus*. *Harpacanthus* was proposed by Dr. Traquair for a spine erroneously referred to *Tristychius*, and not for Agassiz's type-species of this genus. *Pristodus* is not very appropriately placed with undetermined Ichthyodorulites, when Mr. Robert Etheridge's description of *P. Benniei* [1] is taken into account. Moreover, it is satisfactory to be able to add that one of the most characteristic of Ichthyodorulites, *Asteracanthus*, has quite lately passed to its correct systematic position, having proved to belong to the Cestraciont Shark with the teeth named *Strophodus*.[2]

A. S. W.

(*To be continued.*)

II.—Geological and Natural History Survey of Canada. Annual Report (New Series), Vol. II. 1886. Accompanied by Geological and Topographical Maps, Sections, Plates, and Woodcuts. Royal 8vo. pp. 976 and xxix. (Montreal, 1887.)

IT will only be possible in the limited space at our command, to give a very brief account of the contents of this large volume, which contains the reports of the Field Geologists and of others connected with the Survey, commencing with a "Summary Report" by the Director. Each of the thirteen reports which make up the volume are, as usual, distinguished by a letter of the alphabet and separately paginated, with a view to their separate issue. We shall take them seriatim, omitting Mr. J. B. Tyrrell's report, which has already been reviewed in this Magazine.[3]

The Director's report contains a brief résumé of the operations of the Survey for the year 1886, and is especially interesting for the information it gives respecting the mineral products of the Dominion, samples of which were exhibited at the Indian and Colonial Exhibition, South Kensington, 1886. The following are particularly mentioned:—plumbago, mica, soapstone, asbestos, gold and silver ores, manganese, petroleum, ochres, slate, granites and marbles, agates, &c., phosphate.

The reports of the Field Geologists begin with that of Dr. George M. Dawson (pp. 1B—129B);—"On the Northern part of Vancouver Island, from Comox to Quatsino Sound, with the coasts of adjacent Islands, and portions of the mainland."

The report is divided into "General Geology" and "Descriptive Geology." The Queen Charlotte Islands (southern half) and

[1] Geol. Mag. [2] Vol. II. (1875), p. 243, Pl. VIII. Figs. 3, 4.
[2] Ann. Mag. Nat. Hist. [6] vol. ii. p. 336, pl. xii.
[3] August, 1888.

Vancouver Island (northern half) form portions of a single axis of elevation, which here constitutes the western member of the Cordillera. The similarity of the rock formations in these two regions is "so close as almost to amount to identity." Their relations are exhibited in the table below:—

	Queen Charlotte Islands.	Northern Part of Vancouver Island.
Upper Cretaceous.	A. Upper shales and sandstones, 1500 feet.	Port McNeil beds (?). A. Upper shales.
Middle Cretaceous.	B. Coarse conglomerates, 200 feet. C. Lower shales and sandstones, with coal, 5000 feet. D. Agglomerates, 3500 feet. E. Lower sandstones, 1000 feet?	B. Coarse conglomerates. C. Lower sandstones and shales, with coal. D. Wanting. E. ,,

In the northern part of Vancouver Island rocks of volcanic origin, forming portions of a stratified series of great thickness, are abundant. They include, besides the volcanic materials, argillites and limestones, holding Triassic fossils. These volcanic rocks are classed as diabases and felsites, with occasional examples of diorite.

Associated with the volcanic rocks are limestones, argillites and quartzites, which have been recognized at a number of places, from the northern part of the Strait of Georgia, round the northern end of Vancouver Island, and in Quatsino Sound. This intercalated zone is at one place on the north coast of Vancouver Island estimated to be 2500 feet thick. As no complete section of the volcanic rocks with the alternating sedimentary materials could be made out, recourse was had to the fossils contained in the latter for determining the age of the whole series, which was found to be that of the Alpine Trias. The fossils upon which this determination was arrived at belonged to the following species:—*Monotis subcircularis*, Gabb, *Halobia* (*Daonella*) *Lommelli*, Wissmann; *Aulacoceras Carlottense*, n. sp.; *Arcestes Gabbi*, Meek; *Celtites* (?) *Vancouverensis*, n. sp. The descriptions of these species, by Mr. J. F. Whiteaves, are contained in Appendix I. to Dr. Dawson's report. For the entire series Dr. Dawson proposes the name *Vancouver Series*, including under this designation "not only the entire mass of volcanic materials which unconformably underlie the Cretaceous, but also the interbedded limestones and flaggy argillites and quartzites." The series is intended also to include "the similar beds of the Queen Charlotte Islands, as well as those of the southern part of Vancouver Island, to which it was originally applied by Dr. Selwyn in 1871."

The *Vancouver Series*, which are the oldest beds of the district described, are in contact with, or rest upon granitic rocks of later

date, a very anomalous circumstance, for which the following explanation is offered, viz. that probably by the excessive folding together of the rocks the thickness of the series became so great as to bring its lower portions below the plane of fusion. This is shown by the fact that in some places—notably in the vicinity of Blunden Harbour and Seymour Narrows—both the granites and the rocks of the Vancouver Series have been subjected to great pressure in a horizontal direction, causing the fragments in the agglomerates to assume lenticular forms, and to become more or less schistose, and when darker fragments are abundantly present having an almost gneissic lamination. When this was taking place the granites must have been in a plastic state. The granites are almost always hornblendic and grey, or darker in colour, resembling diorites. Dr. Dawson observes that "the relations here exemplified by the contact of the Vancouver Series with the subjacent, though newer granites, precisely repeat those fully detailed by Mr. A. C. Lawson, in his report on the Huronian (Keewatin) and so-called Laurentian rocks of the Lake of the Woods."[1]

The Cretaceous rocks of the northern part of Vancouver Island are probably outliers, originally continuous with an older basin in the Queen Charlotte Islands (see Table). They are found to rest unconformably on an irregular, denuded surface of the older rocks, and have filled pre-existing hollows and valleys in this surface, during a prolonged period of more or less uniform progressive depression.

Coal should be looked for in the more central portions of the basin, because where the beds come in contact with the older rocks, they probably represent only a succession of shore deposits which do not include the entire thickness of the formation.

The Coal-bearing rocks are those of Comox and Nanaimo, which border the south-western shore of the Strait of Georgia forming a belt of rolling country between the mountainous region of the interior of Vancouver Island and the coast. They are largely littoral in character, being composed of comglomerates and sandstones, with intercalated shales, holding marine fossils. It is supposed that these Cretaceous strata underlie a great part of the Strait of Georgia, and that many of the beds were laid down along a sea-margin nearly at the level of the present coast.

On the north side of the west and Rupert Arms of Quatsino Sound there is an area of coal-bearing Cretaceous rocks which has attracted the attention of capitalists, and attempts have accordingly been made to turn it to profitable account, but the records of boring and the geological data obtained in the exploration of this area (called the "Koskeemo Cretaceous area") show that no coal seams of workable extent have been found in it. The entire exposed thickness of the Koskeemo coal-basin is "at least 1500 feet." Records of the borings are given at p. 95B of Dr. Dawson's report.

A brief account is next given of the "Glacial and Superficial Deposits" of the region explored (pp. 99B to 106B). Two great

[1] Annual Report, Geol. Survey Canada, 1885, p. 61CC, et seq.

glaciers are described as having existed at one time in what is now the Strait of Georgia, and in Queen Charlotte Sound. These were described by Dr. Dawson in the Geological Society's Journals for 1878 and 1881.

Appendix I. of the report contains Triassic and Cretaceous fossils described by Mr. J. F. Whiteaves; the former are enumerated above, the latter are as follows:—*Aucella Piochii*, Gabb, *Yoldia arata*, Whiteaves, *Astarte Packardi*, White, *Opis Vancouverensis*, Whiteaves, *Pleuromya lævigata*, Whiteaves, *Placenticeras occidentale*, n. sp., *Scaphites Quatsinoensis*, Whiteaves.

Appendix II. is a list of plants obtained on Vancouver Island and adjacent coasts in 1885 by Professor Macoun. Appendix III. is a record of meteorological observations taken on the coast of British Columbia, June to October, 1885.

This excellent report is illustrated with a geological map of Vancouver Island and the adjacent coasts on a scale of eight miles to an inch.

Mr. R. G. McConnell supplies a report "On the Geological Structure of a portion of the Rocky Mountains, accompanied by a section measured near the 51st Parallel," in the vicinity of the passes followed by the Canadian Pacific Railway.

The following formations were met with, and are represented in the coloured sections accompanying the report, viz.

Mesozoic 5000 ft.	Cretaceous	Kootanie Group to Benton.
Palæozoic 29,050 ft.	Carboniferous passing down into Devonian ..	Upper and Lower Banff Series
	Devonian	Intermediate Limestone.
	Silurian	Halysites Beds.
	Cambro-Silurian	Graptolitic Shales. Upper part of Castle Mountain Group.
	Cambrian	Lower part of Castle Mountain Group. Bow River Group.

The rocks here enumerated are exposed along the Bow and Wapta Valleys, from Banff westward to Golden City on the Columbia. Some new names (Banff limestone series, Intermediate limestone, Halysites beds, Graptolitic shales, and Castle Mountain Group) are introduced, because some of the groups could not be correlated exactly with rocks found in the southern part of the range as described in the various United States reports. It may be mentioned that the Graptolites of the "Graptolitic shales" were submitted to Professor Lapworth for identification. The following species were recognized:—*Didymograptus*, n. sp., allied to *D. enodus*, Lapw., *Glossograptus ciliatus*, Emmons, *G. spinulosus*, Hall, sp., *Cryptograptus tricornis*, Carr. sp., *Diplograptus angustifolius*, Hall, *D. rugosus*, Emmons, *Climacograptus cælatus*, Lapw., with doubtful species of *Phyllograptus*, etc.

Concerning these fossils, Professor Lapworth observes:—"The fact that these Graptolites have been obtained from the distant

region of the Rocky Mountains gives them an especial interest, as few Graptolites have hitherto been noticed from that region." They are referred by him to the age of the Utica slate, or to the Trenton-Utica fauna of the United States and Canada.

Mr. A. P. Low's report (pp. 1 F—24 F) refers to the tract of country between lake Winnipeg and Hudson's Bay, with notes upon the formations met with along the route followed by the explorer. These consisted of Laurentian, Huronian, Cambro-Silurian [Ordovician], Silurian, and Post-Tertiary (Drift). The report contains also a list of rare plants collected, and concludes with an Appendix containing meteorological observations.

Dr. Robert Bell's report (pp. 1 G–38 G) contains an account of "An Exploration of portions of the Attawapishkat and Albany Rivers, Lonely Lake to James' Bay. Besides recording the geological features of the country passed through, observations were made upon its physical aspect, soil, climate, vegetation, etc., as far as these could be noted in a boat voyage. The rocks met with on the Albany river (upper part) consisted of hornblende-schist, granites (cut by dykes of diorite), and gneisses. Huronian rocks (hornblende schists) made their appearance in some parts of the river. At Lake Lansdowne (an expansion of the Albany) rocks of Silurian and Devonian age, the latter fossiliferous, made their appearance.

The extent of the Palæozoic rocks west and south-west of James' Bay leads to the inference that they occupy an area "as extensive as the whole region between the Ottawa River and Lakes Ontario, Erie, and Huron." No evidence was found of the presence of Carboniferous rocks in this great basin.

This report concludes with a description of the Drift deposits (principally Boulder-clay) overspreading the Palæozoic area westward of James' Bay. These deposits were estimated to have a thickness ranging between 30 and 90 feet. The report is illustrated with photo-engravings of views upon the Boulder, Attawapishkat, and Albany Rivers.

Mr. R. W. Ells treats in his report (pp. 1 J–70 J) of the geology of a portion of the Eastern Townships (Province of Quebec) "relating more especially to the counties of Compton, Stanstead, Beauce, Richmond, and Wolfe." The report is accompanied by a geologically coloured quarter-sheet map of this part of the Province, on a scale of 4 miles to 1 inch. The geological systems recognized were the following:—

Silurian.	Cambrian.
Cambro-Silurian [or Ordovician].	Crystalline and igneous, volcanic, and plutonic.

The Silurian rocks, which consist of limestones (sometimes fossiliferous), calcareous slates, and conglomerates, associated with dolomitic slates, are much involved with the underlying older rocks, so that they were formerly mistaken for parts of the older systems. The Cambro-Silurian rocks consist of "graphitic, blackish or dark-grey limestone, with, in several localities, associated slates and sandstones," which were formerly regarded as of Silurian age, or, in

part, Lower Devonian, but are now recognized by their unconformability to the Silurian, as well as by their fossil contents, to belong to the Cambro-Silurian. Intrusions of granite are common in the rocks of this system, and there is frequent evidence of metamorphic action in the condition of the sandstones and limestones. The Cambrian is represented by slates, sandstones—sometimes quartzose—quartziferous schists and conglomerates. The latter are generally unconformable to the slates and limestones of the Cambro-Silurian above, and to the "underlying ridges of crystalline rocks, from the débris of which they are largely formed." The pre-Cambrian rocks form some of the mountain ranges of the district (Stoke Mountain, etc.), and are composed of hard felspathic schists, gneissic felsite, granitic gneiss, talcose and micaceous schists, with, in some places, masses of granitic and dioritic rocks, "the whole presenting a marked resemblance to Huronian strata." The "copper-bearing rocks" of the Eastern Townships, which are of pre-Cambrian age, are described by the author of this report as strikingly similar to the Archæan rocks of England and Scotland, and those of Wales known as the Dimetian, Arvonian, and Pebidian, of Hicks. "Whatever may be the exact age of these altered rocks," adds Dr. Ells, "their present aspect entitles them to be classed as very ancient sediments." The crystalline and igneous rocks consist of granitic, dioritic, and serpentinous rocks, and they constitute lofty ranges of hills, such as Megantic Mountains, Orford and Victoria Mountains, etc. Some observations upon the drift deposits are supplied by Dr. Ells, who endeavoured to ascertain their connection with the auriferous character of the sand and gravel which are widely distributed in the region he explored. He considers that the probable source of the gold of the Townships is in the areas of Cambrian slates which flank the old ridges of the Maine and New Hampshire boundary and the central axis, and that local glaciers were probably instrumental in effecting the disintegration of these slates and distributing an auriferous débris over the "great Cambro-Silurian area of Compton, Stanstead, and Beauce counties." Besides gold, the following minerals, viz. copper, silver, chromic iron, antimony-ore, asbestos, soapstone, slate, etc., occur in the district, and are of more or less economic importance.

Mr. R. Chalmers' report (pp. 1 M–39 M) treats of the surface geology (Post-Tertiary) of Northern New Brunswick and South-Eastern Quebec. It is illustrated with two maps each on a scale of four miles to 1 inch, having the locality and superficial extent of the various formations defined upon them. The surface deposits met with are divided by the author into two series, viz. those of fresh-water, and those of marine origin, the former comprising peat-bogs, shell-marl, lacustrine and fluviatile marshes, river-terraces, kames, etc., the latter, estuarine flats, salt marshes, sand dunes, Saxicava-sand Leda-clay, and kames of marine origin, etc., and lastly till or boulder clay, moraines, and erratics.

Messrs. L. W. Bailey and W. McInnes report upon their explorations carried on in portions of the counties of Victoria, Madawaska,

Northumberland and Restigouche, New Brunswick. Their report is accompanied with a geologically coloured map on a scale of four miles to one inch. One of the objects of this Survey was to determine "the succession of the Silurian strata in the northern portion of the province, and their relations to other systems." The formations met with were the following :—

Lower Carboniferous.
Devonian.
Silurian.
Cambro-Silurian.
Pre-Cambrian.
Granite and related rocks.

The Lower Carboniferous rocks consist mainly of red sandstones, grits and conglomerates, with extensive beds of gypsum, near the top of the formation. The Devonian is represented by a small patch of soft calcareous sandstones and slates, of Oriskany age, as shown by the fossils, determined by Mr. H. M. Ami. Calcareous slates, fossiliferous in places, are the prevailing rocks of Silurian age. The Cambro-Silurian consists chiefly of hard quartzites and slates, apparently unfossiliferous; other rocks of this system are of a more highly altered, schistose, and foliated character. The Pre-Cambrian rocks are hard crystalline felsites, gneisses, felspathic and other schists, all highly contorted. Granite occurs in two areas, and is of similar character and age (Devonian) to that which is found in intrusive masses further to the south.

A voluminous report is contributed to the volume by Mr. Hugh Fletcher (pp. 1 P–128 P) containing an account of explorations and surveys in the counties of Guysborough, Antigonish, and Pictou, Nova Scotia. This report embodies the results of work (mostly topographical) done during the summers of 1882–1886. A map of the region on a scale of 1 mile to an inch has been constructed.

The physical geography of the district presents no features worthy of special note. The highest land extends along the shores of the Gulf of St. Lawrence, from Cape George to the East River of Pictou, but the highest summits rarely exceed 1000 feet, and deep and broad valleys are cut by the rivers flowing into the Gulf. The geological systems recognized in the area included in Mr. Fletcher's explorations are the following :—

Permian.	Silurian.
Carboniferous.	Cambro-Silurian.
Devonian.	Pre-Cambrian.

There are associated volcanic rocks in all but the Permian.

The Carboniferous rocks, which are the most important in the series, "occupy three well-marked belts, often folded obliquely to the longer axis." These are (1) the St. George's Bay basin; (2) the the Merigomish basin; (3) the St. Mary's basin; the latter holding fossil plants, which would indicate either a Millstone Grit or Lower Carboniferous age; but the altered aspect of the rocks would rather refer it to the latter.

The volcanic rocks belong to several distinct periods which are

provisionally referred to the following groups:—felsites, syenites and schists to the pre-Cambrian; igneous rocks cutting Lower Cambro-Silurian conglomerates; volcanic rocks contemporaneous with Middle and Upper Cambro-Silurian. Dykes cutting through Silurian, Middle, and Upper Devonian strata, and volcanic rocks contemporaneous with Middle Devonian. Finally the Carboniferous conglomerate is traversed by volcanic rocks and dykes of contemporaneous origin.

Several pages of this report are devoted to an account of the surface geology, scenery, climate, agriculture, and economic minerals, of the district explored. The latter include coal, iron, gold, gypsum, phosphate of lime, building stones, etc.

Mr. E. R. Faribault reports (pp. 129 P–163 P) upon the Lower Cambrian rocks of Guysborough and Halifax counties, Nova Scotia, including the gold-bearing slates and quartzites, "which cover nearly one-half the superficies of the Province, that is, according to various authorities, from 6000 to 7000 square miles."

A further contribution by Dr. G. M. Dawson (pp. 1 R–62 R) is supplied to the volume under review in the shape of "Notes to accompany a geological map of the northern portion of the Dominion of Canada, east of the Rocky Mountains." The map is "designed primarily as a supplement to the general geological map of the southern portion of the Dominion, published by the Geological Survey in 1884, for the compilation of the western part of which the writer [Dr. Dawson] was largely responsible."

The "notes" accompanying the map form a succinct account of the geology of the most northerly part of the continent, embracing the Arctic regions. The information concerning these lands is derived from many scattered sources, including the well-known works of voyagers in the polar seas from Ross to Nares, and Greely. A very full bibliography of Arctic travel is appended to the "notes."

The prevailing rocks of these northern lands are Archæan, and they probably form the greater part of Greenland, and "doubtless underlie, at no great depth, the entire Arctic Archipelago." The different subdivisions of the Archæan occurring in the more southerly portions of Canada are repeated in the north; amongst these the Huronian is met with on the west coast of Greenland, probably on the Labrador coast, and on the west coast of Hudson's Bay. Rocks of similar character to those of the Keewenaw or Animikie of the Lake Superior region, have been recognized in the vicinity of the Coppermine River, and are probably of Lower Cambrian age. This formation is of such wide extent that Dr. Dawson considers that it ranks as "one of the most important geological features of North America." It is composed largely of volcanic rocks, and is apparently everywhere unconformable to the underlying Laurentian and Huronian systems. The Silurian and Cambrian systems, which are also widely developed, consist chiefly of "pale limestones, often of a yellowish or cream colour, and frequently more or less dolomitic. They rest everywhere unconformably on the Archæan or on the Cambrian rocks." The extent

and relations of the rocks of Devonian age have not yet been satisfactorily determined, but their occurrence is recorded on the Mackenzie River, and their presence is inferred in the limestone formation which stretches from the vicinity of Lake Winnipeg to the mouth of the Mackenzie, and thence to Baffin's Bay and Grinnell Land. A revision of the fossils from the Mackenzie and the Arctic basin is recommended as very desirable.

An important series of Coal-bearing rocks of Lower Carboniferous age (of the so-called "Ursa Stage" of Heer) are distributed in the Arctic Archipelago, but no estimate appears to have been formed of their thickness, nor indeed of that of any of the older rock-series in the Arctic basin. Rocks of Liassic or Jurassic age, of unknown extent, are said to occur in the northern part of the Arctic Archipelago. The so-called "Miocene" of Greenland and Grinnell Land "is now regarded as equivalent to the Laramie, or at least not newer than the Eocene." The superficial deposits are not dealt with in these notes, as the information respecting them is not such as can be expressed upon a geological map. A few observations upon glacial phenomena are however added.

Mr. Coste (pp. 1 S—85 S) supplies some useful statistical tables, with explanations, of the "production, value, exports and imports, of minerals in Canada during the year 1886 and previous years."

Mr. G. C. Hoffmann, assisted by Messrs. F. D. Adams, and E. B. Kenrick, gives the results of work done in the chemical laboratory of the Survey. There is a full index at the end of the volume.

A. H. F.

III.—Richmond Coal Field, Virginia.

THE scanty literature of the Virginia Triassic has lately been increased by the appearance of a pamphlet by Mr. William Clifford,[1] describing this complicated field and illustrating the structure by maps and sections. The history, geography, the mining methods and difficulties are concisely outlined. There are also given some of the characteristics of the rocks of the basin, and analyses of coals and natural cokes. As a whole the author dwells more on the economic and engineering side, than on the purely geologic; but as he devotes some space to a discussion of the latter, I would venture to criticize, or at least call the attention of others, to his facts and some theoretical conclusions based thereon.

The statement of first importance, on which many deductions rest, is that the strata thin out at the outcrop, or, to give the exact words, "the rocks thin out toward the sides of the basin as though, during their deposition, the rock material had slid somewhat down the steep sides on which it was thrown down."

A careful exploration made this year failed to give conclusive evidence of such a general thinning. It is true the opportunities now of examining the strata are very few—and without doubt there

[1] Richmond Coal Field, Virginia, by William Clifford, M.E., read before the Manchester Geological Society, December 6th, 1887.

are beds once exposed in mines now closed which tend to give support to the opinion just quoted.

The deduction, that the rock material was deposited on a steep slope, in all probability will not stand searching investigation. There is far too much stress put upon the assumption made by Lyell, and since then unquestioned, that the *present* basins were basins at the *beginning of the Triassic*, and that the irregularities are due to deposition on uneven surfaces rather than to subsequent bending and crushing. The evidence, on the contrary, points to the fact that this coal series was deposited in a horizontal position. Not enough allowance has been made for the effect of subsequent crushing and erosion of these soft rocks.

It is well known that one of the principal coal beds, dipping at an angle averaging 30°, has been worked along the strike for, say a mile, and has been explored on the dip for 1500 feet, equivalent to a vertical depth of 750 feet. Throughout this breadth of 1500 feet it maintains approximately a uniform thickness. Surely no theory can satisfactorily explain this uniformity of thickness through such a *vertical* range, without admitting the original horizontality of the coal floor. The author of the paper cannot have carefully considered his position when he says, "The coal seams in the main basin are equally thick at the outcrop and in the deep; the tenacity of the roots having given the coal plants a firm hold up the steep sides of the trough."[1] Not only the uniform thickness of the coals on the dip, but the laminæ of shale between the coals, the fire clays and impure limestones between the beds, all testify to the original horizontality of these beds. And the innumerable "troubles," as the areas of crushing and faulting are locally called, give the strongest proof of the enormous subsequent movements.

A conclusion of great practical importance depends upon the confirmation of this set of facts—and this is the persistence of the coal throughout the bottom of the main basin. If it is conceded that the strata do not thin at the outcrop, and that they were deposited on horizontal surfaces, then all the hypotheses of Lyell, Lesley,[2] and others, based on the supposition that the bottom of the present basin was under different conditions of depth and water currents from the present sides, fall to the ground, and we have no reason to suppose that the beds in the centre of the basin differ in original characteristics as to number, thickness, and continuity of coals from those at the outcrop.

It does not follow from what has been said that any one workable coal is continuous across under the basin to the outcrop on the other side. On the contrary, this is probably not the case. The identification of any one coal seam for a distance of even one or two miles is a matter of great uncertainty, owing to the number of the seams, the changes in the thickness both of the coal and accompanying shales, the bending and crushing to which all have been subjected,

[1] Page 7, idem.

[2] Quoted in McFarlan's "Coal Regions of America," p. 512, from Lesley's U.S. Railroad and Mining Register, Philadelphia.

and the rapid decomposition of the whole series. When the change of thickness of the coal beds and the large number of thin coals—usually overlooked—are given due consideration, strong doubt is thrown upon the identifications that have been often attempted, between the coal in one mine and that in another mine a mile or more away. The probabilities are that the coal of economic importance in the one mine is represented by some one of the smaller neglected coals in the other.

The areas of crushing and faulting are, owing to the softness of the rocks, more impervious to water than the undisturbed portions of the beds. In this I differ from Mr. Clifford, when he says, "The measures which overlie the coke seams are very much fissured, and consequently the pits working coke are more heavily watered than coal pits. Some of the most promising ones in the northern end of the field had to be abandoned on that account."[1] This idea probably arose from the fact that the workings in the northern portion of the coal area carried on by many owners, at various times, without system, have intersected each other, so that water from one coke pit will now flow to any other. Thus, the perviousness to water, which has caused the abandonment of these mines, is due to artificial and preventable rather than natural or wide-spread causes.

F. H. Newell.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January, 23, 1889.—W. T. Blanford, LL.D., F.R.S., Vice-President, in the Chair.—The following communications were read:

1. "On the prevailing Misconceptions regarding the Evidence which we ought to expect of former Glacial Periods." By Dr. James Croll, F.R.S. Communicated by T. G. Bonney, D.Sc., F.R.S., F.G.S.

The imperfection of the geological record is greater than is usually believed. Not only are the records of ancient glacial conditions imperfect, but this follows from the priciples of geology. The evidence of glaciation is to be found chiefly on *land-surfaces*, and the ancient land-surfaces have not, as a rule, been preserved. Practically the several formations consist of old sea-bottoms, formed out of material derived from the degradation of old land-surfaces. The exceptions are trifling, such as the under-layers of coal-seams, and dirt-beds like those at Portland. The transformation of an old land-surface into a sea-bottom will probably obliterate every trace of glaciation; even the stones would be deprived of their ice-markings; the preservation of Boulder-clay, as such, would be exceptional. The absence of large erratic blocks in the stratified beds may indicate a period of extreme glaciation, or one absolutely free from ice. The more complete the glaciation the less probability of the ice-sheet containing any blocks, since the rock would be covered up. Because there are no large boulders in

[1] Clifford's paper, p. 13.

the strata of Greenland or Spitzbergen, Nordenskjöld maintains that there were no glacial conditions there down to the termination of the Miocene period. The author maintained that glaciation is the normal condition of polar regions, and if these at any time were free from ice, it could only arise from exceptional circumstances, such as a peculiar distribution of land and water. It was extremely improbable that such a state of things could have prevailed during the whole of the long period from the Silurian to the close of the Tertiary.

A million years hence it would be difficult to find any trace of what we now call the glacial epoch; though if the stratified rocks of the Earth's crust consisted of old land-surfaces, instead of old sea-bottoms, traces of many glacial periods might be detected. The present land-surface will be entirely destroyed in order to form the future sea-bottom. It is only those objects which lie in existing sea-bottoms which will remain as monuments of the Post-tertiary glacial epoch. Is it, then, probable that the geologist of the future will find in the rocks formed out of the non-existing sea-bottom more evidence of a glacial epoch during Post-Tertiary times than we now do of one, say, during the Miocene, Eocene, or Permian period? Palæontology can afford but little reliable information as to the existence of former glacial periods.

2. "On Remains of Eocene and Mesozoic Chelonia, and on a Tooth of (?) *Ornithopsis*." By R. Lydekker, Esq., B.A., F.G.S.

This communication treated in the first place of remains of Chelonia from the Cambridge Greensand, Wealden, and London Clay. Firstly, *Rhinochelys*, from the Cambridge Greensand, was considered to indicate a Pleurodiran type; and four new specific names were proposed, viz. *R. macrorhina*, *R. brachyrhina*, *R. Jessoni*, and *R. cantabrigiensis*. From the same deposits a skull was described which was considered to indicate a new species of *Chelone*, for which the name *C. Jessoni* was proposed. Other remains of marine Chelonians from these beds were regarded as indicating a Turtle allied to the Loggerhead, and were provisionally referred to the genus *Lytoloma*, as *L. cantabrigiensis*. In the course of the description, it was proposed to replace the name *Enclastes* (pre-occupied) by *Lytoloma*. Of other Chelonidæ, the new generic name *Argillochelys* was proposed for *Chelone cuneiceps*, Owen, of the London Clay, which would also include some other forms from the same beds. A shell of a *Plesiochelys* from the Wealden of the Isle of Wight was regarded as indicating a new species, which was named *P. Brodiei*.

It was also shown that *Chelone gigas*, Owen, of the London Clay, did not belong to the Chelonidæ at all, but indicated a species of the genus *Psephophorus*—a member of the Dermatochelydidæ. The next section of the paper described a peculiar mandibular symphysis from the London Clay, which was taken to indicate a new genus of Chelonia, to be named *Dacochelys*; and it was suggested that *Emys Delabechei*, Owen, might be the same form.

The paper concluded with a notice of a tooth from the Wealden, of the same general type as one previously referred by the author to

Ornithopsis; and it was shown that teeth from the Portlandian of Boulogne, which had been described as *Neosodon* and *Caulodon*, and regarded as Iguanodont, were likewise of the same general type. It was also shown that *Cardiodon*, Owen, from the Forest Marble, belonged to the same group.

3. "On the Dentition of *Lepidotus maximus*, Wagn., as indicated by specimens from the Kimeridge Clay of Shotover Hill, Oxford." By R. Etheridge, Esq., F.R.S., and H. Willett, Esq., F.G.S.

The paper commenced with a list of fourteen species of *Lepidotus* known in England, from beds between the Lias and Upper Chalk inclusive, and an account of the range of the Lepidosteoid fishes from Permian times to the present day followed. The occurrence of separate teeth of *Lepidotus maximus*, Wagn. (= *Sphærodus gigas*, Ag.), in the *Exogyra-virgula* zone of Shotover and Kimeridge, has been previously recorded; but in the present communication four specimens of jaws containing teeth were noticed.

I. Comprises the upper dentition; it belongs to the same species and, possibly, to the same individual as No. IV. Eighteen teeth occur in its two fragments.

II. Contains two teeth, an upper and a lower, belonging to the same species as No. IV.

III. Probably the right dentary bone appears to belong to a distinct species. It is very perfect, and exhibits sixteen teeth, of which the successors of six are exposed on the underside. The marginal series comprises the seven smallest teeth, those placed most inwardly being the largest. Compared with the dentary bone of those species of which that element is already known, the fossil approaches most closely to *Lepidotus maximus*, Wagn., but the bone is broader in proportion to its length, and the teeth are more numerous.

IV. Corresponds undoubtedly to *Lepidotus maximus*, Wagn. The dentition of this specimen does not, however, appear to belong to the left upper jaw, but to the dentary bone. Its upper surface contains seventeen teeth, and the lower, or successional, series consists of fifteen = 32 in position.

II.—February 6, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Occurrence of Palæolithic Flint Implements in the neighbourhood of Ightham, Kent, their Distribution and probable Age." By Joseph Prestwich, D.C.L., F.R.S., F.G.S.

The author stated that Mr. Harrison of Ightham has discovered over 400 palæolithic implements lying on the surface at various heights and over a wide area around Ightham. A description of the physiography of the district and the distribution of the various gravels and drifts was given, and in the absence of fossils, attention was called to the different levels at which the deposits occurred, and to their physical features and characters. Besides the river-gravels, two groups of unclassed gravels were described, one occupying a low level, and the other levels higher than that to which the river-drifts reach; the latter is of varied composition.

In the case of the Shode valley, only beds below the contour-level of 350 feet in its upper part, and of 300 feet or less in its lower part, can be referred to the former action of the Shode, and those above this belong to a high-level drift of uncertain age. The composition of the various gravels was described in detail.

The implements are found on the surface of the land at all levels up to 600 feet, and Mr. Harrison has discovered them at 40 localities in the hydrographical basins of the Shode, the Darent, the Leybourne stream, and in part of the Thames basin. Two groups of implements extend far beyond the limits assigned to the river-drifts formed since the present hydrographical basins were established, and must be accounted for by some other means than those in connection with the former *régime* of the existing streams. A description of the general characters and variations observable in the implements was given. It is evident from the condition of most of the implements, that they have been imbedded in some matrix which has produced an external change of structure and colour. In the case of the river-gravel sites, the question presents no difficulty. Three classes of implements have been found—(i.) where the flint still shows some of its original colour; (ii.) those of which the surface has turned from black to white, has been altered in structure, and acquired a bright patina, and which shows no trace of wear; (iii.) those of which the flint has also lost its original colour, but has been stained, and is with or without patina; these are generally much rolled. The characters of the first call for no comment. Those of (ii.) and (iii.) are very marked, and there is no difficulty in referring each to a distinct matrix. The implements of class ii. have been embedded in a stiff brick-earth, generally of a reddish colour, and those of class iii. seem to have lain in ferruginous beds of sand or gravel. Reasons were given for supposing the surface to have been once covered with a deposit of clay or loess, since denuded except where preserved in pipes, and that a continuous plane descended from the high range of the Lower Greensand to the Thames valley, which has since been lowered 300 feet or more. It was also shown that the high-level deposits were formed anteriorly to the Post-glacial drifts of the Medway and Thames Valleys. It is probable that the loess is a deposit from flood-waters, and that some of it may be referred to the Medway flowing at a higher level; but the highest deposits cannot be so accounted for, and the author referred to the possibility of glacial action, without insisting on it. The deposit on the Chalk-plateau is abruptly cut off by the river valleys, and the rudest forms of implements, such as those of Ash and Bower Lane, occur on this plateau at from 500 to 550 feet, and the author thinks they may possibly be of Pre-glacial age. The changes which have taken place in the physiography of the district, and the great height of the old chalk-plateau, with its clay-with-flints and southern drifts, point to long intervals of time, and to the great antiquity of the rude implements found in association with these drifts. That the removal of the material indicates the existence of agents of greater force than those operating under the present river *régime* closes up the time

required for the completion of the great physical phenomena, though the author's inquiry tends to carry man further back geologically than is usually admitted.

CORRESPONDENCE.

A CORRECTION.—MESOZOIC MONOCOTYLEDON.

SIR,—In my review of Mesozoic Angiosperms in the GEOLOGICAL MAGAZINE for May, 1886, I was induced to figure a specimen from the Woodwardian Museum, which I found placed in a case among Jurassic plants, and which I was informed had come from the Yorkshire Oolites. It is no plant, and really comes from Ascension, and presents one of those extraordinary cases of mimicry which all students of fossil plant-remains are familiar with. While presenting the external form of a fruit it exhibited no trace of internal vegetable structure, and I therefore abstained from cutting a section for the microscope which would have revealed it true nature. It is evidently, as pointed out to me by Prof. Judd, a gobbet of lava, which has been ejected in a molten state to a great height, and has taken its ropy and elongated form in its descent through the air. Knowing its origin, it is easy to see how the mimic spathe has been formed by the overrunning of the still melted top down one side of the already congealed body, like a guttering candle; the indistinct seeds being minute air-bubbles caught between the two surfaces. I fortunately forbore to give it any sort of name.

In endeavouring to collect together and describe the rare and scattered, ill-preserved, and mineralized plant-remains from the marine Mesozoic beds which alone fill in much of the gap between the Carboniferous and the Tertiary, the most experienced are liable to err. Only a few days since some concretions were sent to me by a well-known geologist as plants.

Unfortunately many of our museums abound with specimens to which hypothetical localities and imaginary formations are assigned. I spent the best part of a day in noting down errors of this description in the Tertiary and Cretaceous collection of a northern university museum, and sent them to the Curator, who up till now has not acknowledged their receipt. J. STARKIE GARDNER.

A SOUTH AFRICAN GEOLOGISTS' ASSOCIATION.

SIR,—You will be pleased to know that a "South-African Geologists' Association" has been established at Grahamstown in connection with the Albany Museum there. Dr. Atherstone, F.G.S., has been appointed its first President; and there are Vice-Presidents in Cape Town, Natal, the Free State, and Transvaal. Dr. Atherstone had long endeavoured to get up such a Society, and the Exhibition there gave the opportunity for carrying it out. T. RUPERT JONES.

Dr. J. W. Spencer, Professor of Geology at the University of Georgia, has been appointed State Geologist of Georgia.